DEWEY B. LARSON

New Light on Space and Time

NEW LIGHT ON SPACE AND TIME

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Beyond Space and Time

NEW LIGHT ON SPACE AND TIME

by

DEWEY B. LARSON

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PREFACE

At the time I first undertook publication of the results of my investigation of basic physical processes it was my belief that those individuals to whom the presentation was primarily addressed, the experts in that field, would have no difficulty in understanding the new theories and concepts developed in my work, and that my major objective should be that of proving the validity of the new theoretical structure. My first book, The Structure of the Physical Universe, therefore outlined the new theories in what I believed was an adequate, although rather brief and highly condensed, manner, and was principally concerned with carrying the development of the theoretical structure into minute detail in a number of areas in order to show that the conclusions derived from the new theories were in agreement with the observed facts to a hitherto unparalleled degree of accuracy and completeness. By this time, however, it has become apparent that existing habits of thought are much more firmly entrenched than I had realized, and that even where an individual has a genuinely receptive attitude toward new ideas it is very difficult for him to accomplish the reorientation of thinking that is necessary for an understanding of the nature and implications of the new concepts upon which my theories are founded. The effectiveness of the proof which I have offered has therefore been lessened to a considerable degree by reason of a widespread inability to understand just what it is that I am proving.

Obviously some more extended and detailed explanations of the new basic ideas are essential, and my more recent publications have been directed toward that end. In *The Case Against the Nuclear Atom* I subjected one of the principal segments of modern physical theory to a searching and critical examination, with the objective of showing that present-day theory, in spite of its impressive accomplishments in many areas, is full of defects and inconsistencies, and fails by a wide margin to meet the demands that are imposed upon it by the continued progress of experimental discovery; hence the door is wide open for the

construction of a new and better theory. In *Beyond Newton* I presented what may be called a "vertical cross-section" of the new and better theoretical structure that I have developed in response to this need, taking one particular subject, gravitation, and following it all the way from the fundamental postulates of the new system down to the minor details, demonstrating how accurately the findings of the new system reproduce the behavior and characteristics of this phenomenon which has presented so many difficult problems to previous theory.

Having thus introduced my work and established its general background in these previous publications, I believe it is now appropriate to present a concise unified picture of the new theoretical structure as a whole—a bird's-eye view of the entire development and this present volume is designed for that purpose. Since the new concepts of the nature of space and time which have emerged from my investigation are the essential elements of the new structure, the plan of the book is to develop the background of these concepts in full detail, and then to explain, somewhat briefly, their application to each of the general fields of physical science, with particular emphasis on the simple and logical answers, usually of a totally unexpected nature, which the new system provides for the major unsolved problems of physics.

In carrying out this program, a certain amount of duplication of material previously published is, of course, unavoidable, particularly since it seems desirable that the book be self-contained, but an effort has been made to hold this duplication to a minimum.

Dewey B. Larson

April, 1965

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It is not, I believe, too much to say that all the vital problems of philosophy depend for their solution on the solution of the problem of what Space and Time are and more particularly how they are related to each other.

Samuel Alexander[1]

The problem of time has always baffled the human mind.

Hans Reichenbach[2]

The modern advances in thermodynamics, relativity, cosmology and information theory, instead of clarifying our insight into this basic notion (time), seem so far only to have added to the general confusion.

Max Black[3]

There will have to be some new development that is quite unexpected, that we cannot even make a guess about.

P. A. M. Dirac[4]

CHAPTER I

Introduction

In my previous publications I have begun the presentation of a new theory of the structure of the physical universe which has emerged as a result of a careful and critical reexamination of basic physical processes on which I have been engaged for more than a quarter of a century. In all essential respects this new theory is just the kind of a product that the scientific world would like to have. It is a *unified* theory; all of the principles governing all sub-divisions of physical activity are deduced from the same premises: two fundamental postulates as to the nature of space and time. It is a *self-consistent* theory; there are no internal contradictions or inconsistencies. It is an *accurate* theory; all of the deductions from the postulates are in full agreement with the results of observation and measurement, within the margin of accuracy of the latter or, at least, are not inconsistent with any of these results. It is an *unequivocal* theory; the consequences of the postulates are specific and definite and at no point are there any recourse to a "postulate of impotence" or other evasive device to avoid admitting a discrepancy. It is a *rational* theory; it provides definite and specific explanations for everything that happens, without calling upon ad hoc forces or transcendental agencies. It is a *complete* theory; the logical and unavoidable consequences of the postulates describe, both qualitatively and quantitatively, a complete theoretical universe, and it is not necessary to utilize any supplementary or auxiliary assumptions, nor is it necessary to introduce the results of observation as a foundation for the theoretical structure, because the theoretical deductions from the postulates provide for the *existence* of the various physical phenomena–matter, radiation, electrical and magnetic phenomena, gravitation, etc.—as well as establishing the *relations* between these entities.

The appearance of a new and revolutionary theory of this kind, one which is actually a complete and comprehensive inter-related system theories, rather than a single theory of limited applicability,

and which is free from the weaknesses and contradictions of existing theories, thereby enabling physical science to overcome the serious difficulties with which it is now faced in many areas, is by no means an unexpected phenomenon. As expressed by Dirac, "Most physicists … are inclined to think one master idea will be discovered that will solve all these problems (of present-day science) together." It is also generally realized that this "master idea" will involve some radical modification of existing thought. Dirac warns us specifically that the "unexpected new development" which he predicts may require a "drastic change in our physical picture," and he goes on to point out that the need for such a change implies the existence of serious conceptual defects in current theories: "This would mean that in our present attempts to think of a new physical picture we are setting our imaginations to work in terms of inadequate physical concepts."[4]

But those who agree in principle that existing ideas must be drastically modified—a category that, as Dirac says, includes "most physicists"—are not nearly so willing to accept any specific proposal, regardless of its credentials, because any really new idea will inevitably conflict with some cherished belief of long standing. From a purely logical viewpoint, the items listed in the first paragraph come about as near as we can expect to get to an ideal theory but, as a rule, scientists are inclined to add one more requirement: the new theory must not disturb existing habits of thought in any more than minor and incidental respects. Some attempts have even been made to set this up as a scientific "principle." Ernest Hutten, for example, expresses the sentiment in this way: "certain logical requirements must be met when theories are constructed. A new theory is to be constructed so that it contains the previous theory as a lower approximation."[5] This sounds more reasonable than a flat refusal to entertain any new basic idea, but it amounts to the same thing; it is a demand that the new theory refrain from disturbing fundamental ideas, that it be an extension or modification of the theory that it replaces, not a substitute for it. Heisenberg makes it even more clear in the following statement that the modern physicist, if he concedes anything at all, will limit his concession to inches:

> Indeed there could apparently be no objection to an assumption that, say, the radium atom possesses hitherto unknown properties which accurately define the time of emission and the direction of

> an alpha particle. However, a more detailed analysis shows that such an assumption would force us to consider as wrong those very statements of quantum theory, which allow an accurate mathematical prediction of experimental results. We have, so far, had every reason to rely on those parts of quantum mechanics. [6]

Here we have a plain statement of the present-day physicist's position: he will not listen to any proposal that would force him to give up basic ideas that have met with much success. No doubt the average layman will be inclined to sympathize with this stand, and the reaction of many reviewers to the contentions advanced in my previous books shows the same attitude. As one of them puts it, his "main criticism" of *The Case Against the Nuclear Atom* is that I have emphasized "every weak point and apparent failure" of the nuclear theory and have paid little attention to its successes.[7] All of these individuals, laymen, reviewers, and eminent physicists alike are missing the point. *It is the weaknesses and failures of a theory that determine its ultimate fate, not its successes.* From the standpoint of ultimate survival, its successes, however great they may have been, are wholly irrelevant. Even Hutten, who wants to perpetuate existing theories by incorporating them into their successors, admits that whatever successes these theories may have achieved are no guarantee of validity. "False theories," he says, "may be quite successful, particularly if they are vague and their meaning cannot be given clearly."[8]

In the final analysis, the validity of a theory cannot be judged by what it *has done;* the crucial test is what, if anything, it *fails to do.* Present-day physicists are quick to recognize this point in application to the theories of their predecessors. The Ptolemaic theories of astronomy, for instance, met all of the demands upon them for more than a thousand years, a record of achievement that far surpasses anything that a modern theory has to offer, yet they were ultimately superseded because improved observational facilities brought new demands which these theories could not meet. Newton's gravitational theory, the most successful physical theory of all time—one which, in spite of some loss of glory in recent years, still remains the basis for all *practical* work in its field—was elbowed aside despite its impressive record, simply because a challenger seemed to offer better explanations for certain obscure phenomena, the true significance of which is still a matter of controversy.

But this principle that a theory cannot rely on past successes and must meet all present-day requirements in order to survive, which seems so clear to the physicists in application to the theories of Ptolemy, Newton, and other scientists of past eras, is not recognized as applying to their own theories. Even though the reviewer admits that "weak points and apparent failures" exist in the nuclear theory, he contends that the successes of the theory warrant its retention. Even though Heisenberg concedes that only "parts" of quantum theory have been successful and that the success is purely mathematical, he still wants to veto any new thought that would "force us to consider as wrong" the basic tenets of the theory.

Unfortunately, this requirement that the physicists wish to impose, the requirement that a new theory must be evolutionary, not revolutionary, and must leave present basic concepts intact, is wholly unrealistic. We cannot have progress without change, and if we propose to take a big step forward, as in this case where we propose to substitute a unified, all-embracing theoretical system for many independent or semi-independent theories of limited scope, there must necessarily be some *substantial* changes in basic concepts, however distasteful this prospect may be to individuals who resent being forced out of the comfortable groove of familiar thought. The physicists who cling to the hope that "drastic changes" can take place without disturbing any of their cherished ideas of long standing are simply daydreaming. The mere existence of difficulties which are serious enough to give rise to frequent predictions of "drastic changes" is sufficient evidence to show that there is something wrong with the *foundations* of existing physical theories and that mere tinkering with these theories will not suffice. There must be a major change that goes all the way down to the root of the trouble.

As Thomas Kuhn characterizes the transition from the old to the new in basic physical theory in his book *The Structure of Scientific Revolutions,* this change is not

> one achieved by an articulation or extension of the old paradigm. Rather it is a reconstruction of the field from new fundamentals, a reconstruction that changes some of the field's most elementary theoretical generalizations … When the transition is complete, the profession will have changed its view of the field, its methods, and its goals.[9]

The new theoretical system, which I am presenting in the current series of publications, involves a major reconstruction of the type to which Kuhn refers, one which is particularly drastic inasmuch as this system is something of a totally different nature from anything previously formulated. I am not presenting a new theory of atomic structure, or a new theory of gravitation, or a new theory of the cosmic rays, or a new theory of electricity and magnetism; I am presenting a theory of the physical universe *from which* complete, consistent, and inter-related explanations of atomic structure, gravitation, the cosmic rays, electricity and magnetism, etc., can be derived. It is not, strictly speaking, a *new* theory of the universe, because nothing of this nature has ever been developed before. No previous theory has come anywhere near covering the full range of phenomena accessible to observation with existing facilities, to say nothing of dealing with the currently inaccessible and as yet observationally unknown phenomena which must also come within the scope of a complete theory of the physical universe.

I realize, of course, that even if I were not challenging some of the most cherished ideas of the scientific profession, far-reaching claims such as those which I am making on behalf of my new system in the foregoing paragraphs would be looked upon with disfavor, if not outright hostility, in scientific circles. Progress in the scientific field consists primarily of successive small advances, with long periods of testing and verification — and occasionally some minor retreats — intervening between the forward steps. Caution and modesty in making claims for new developments have thus come to be regarded as important scientific virtues and broad claims are looked upon as savoring of non-science or pseudo-science. In deference to this prevailing attitude I would be inclined to tone down the presentation and deliberately understate the case for the new system were it not for the fact that this would be, in effect, a gross misrepresentation of what I am offering. When I first undertook this investigation I was aiming at a much more modest goal, but since the ultimate product turned out to be a comprehensive theory of the universe, I do not believe that I am justified in presenting it in any other light than that of a comprehensive theory of the universe.

Furthermore, I have no choice but to emphasize the fact that the agreement between the results of observation and my new theoretical

system, the Reciprocal System, as I call it, because its distinguishing characteristic is the concept of a general reciprocal relation between space and time, is full and complete, since anything short of this would completely undermine the method of proof upon which I am relying to establish the validity of the system. What I am prepared to do is to demonstrate that the mathematical probability of any error in the basic structure of the system is negligible. This can only be done if the structure is specific and unequivocal so that it can be checked against experience, far-reaching so that it can be tested in an extremely large number and variety of applications, and absolutely free from conflict with any positively known fact so that the cumulative effect of the individual tests will establish an overwhelming probability that no conflict exists anywhere. Under these circumstances even a modest amount of modesty would be fatal. Thus I have no option but to present the system in its true colors, and to assert positively and categorically that this system complies fully and explicitly with all of the foregoing requirements for proof by the probability method, and that I am prepared to demonstrate this compliance.

Not only is this the first unified theory of the universe, and the only major physical theory that is prepared to prove its validity; it has another characteristic that should recommend it to those who, like Louis de Broglie, find themselves somewhat bewildered by "theories which, for the moment, strike one as having been lost in abstraction."[10] *The Reciprocal System portrays the universe as basically simple, understandable, and wholly rational.*

There is no scientific basis upon which we can justify a contention that the universe *must* have these characteristics, but they are commonly recognized as desirable, and even the scientists who feel that they are forced to abandon one or more of them in the construction of new theories do so regretfully and with a sense of loss. Niels Bohr, for example, admitted that the "resignations" of this kind that had to be made in the development of quantum theory "might well be regarded as a frustration of the hopes, which formed the starting point of the atomic conceptions."[11] But modern science has reconciled itself to frustration and has come to the conclusion that an understandable general theory is unattainable. "Insistence on the postulate of complete logical clarification would make science impossible,"[12] says Heisenberg. We are even told that for further progress we must give up whatever

small degree of comprehensibility still remains in modern theory. Čapek, for instance, contends that "A radical abandonment of visual and imaginative models in modern physics is absolutely imperative if the meaning of the present crisis in physics is not to escape us entirely."[13]

This present work does what Heisenberg claims is impossible: it presents a theory derived in a clear and logical manner from definite and unequivocal initial postulates, one that is both consistent with all experience and fully understandable in all of its aspects. Furthermore, in defiance of Čapek's dictum, it lends itself readily to representation by pictures and models. For example, the structure of the atom, as it emerges from the theoretical development can be quite clearly represented by nothing more than two pieces of cardboard, as will be brought out in the subsequent discussion. I do not by any means contend that the new theoretical structure is so simple that anyone should grasp it in its entirety at first sight. But, unlike "modern physics," the Reciprocal System has no aspects, which are *inherently* vague or incomprehensible, and there is nothing in the theory itself, which should stand in the way of a clear understanding. Whatever difficulty may be experienced in this respect will be due to roadblocks set up by previous commitments to other lines of thought. As expressed by Dyson:

> The reason why new concepts in any branch of science are hard to grasp is always the same; contemporary scientists try to picture the new concept in terms of ideas, which existed before. [14]

At this juncture the question naturally arises, Just how was this accomplished? How is it possible for the Reciprocal System to attain a *full* agreement with experience without sacrificing any of these desirable features—simplicity, understandability, and rationality—when modern physics has had to sacrifice all of them to attain a partial agreement with experience? The details of the methods that were utilized will be discussed later, particularly in Chapter IV, but it is possible to summarize the answers to such questions as the foregoing by borrowing an expression from Bridgman and saying that what this new work has done, in essence, is to widen the horizons of physical theory.

One of the unfortunate consequences of the inability of modern science to arrive at logical and rational solutions of its major problems has been the emergence of a tendency to lay the blame on nature itself

rather than on the inadequacies of the theorists' efforts. As expressed by Bridgman in the statement to which reference has just been made:

> The revolution that now confronts us arises from the recent discovery of new facts, the only interpretation of which is that our conviction that nature is understandable and subject to law arose from the narrowness of our horizons, and that if we sufficiently extend our range we shall find that nature is intrinsically and in its elements neither understandable nor subject to law.[15]

The difficulty here is that Bridgman (together with the community of physicists whose views he is expressing) has failed to distinguish between experimental horizons and theoretical horizons. Nature is rational and understandable when the horizons of the theories by which man endeavors to reach an understanding of that which he observes are coextensive with his experimental and observational horizons. A century ago this was true. At that time the experimental range did not extend beyond the region in which the physical laws formulated by Newton and his successors—the so-called "classical laws"—are valid, and as a result the known physical phenomena were, in general, understandable and capable of explicit theoretical representation. Subsequently the advance of experimental science has carried observational knowledge into entirely new areas, and it has been found that in these areas the classical relations no longer hold good. Modern physicists have therefore attempted to find laws of wider scope and greater generality, but they have found it impossible to secure this wider coverage and also maintain the clear and unequivocal nature of the classical relations. As Bridgman says, the only interpretation which they have been able to place on these facts is that nature is not inherently rational or understandable, and modern theories have therefore been constructed without regard for these two qualities which had previously been regarded as prime requisites.

Not everyone is content to accept this situation. Erwin Schrödinger, for instance, says that "In the face of this crisis (in physical theory), many maintain that no objective picture of reality is possible. However, the optimists among us (of whom I consider myself one) look upon this view as a philosophical extravagance born of despair."[16] Louis de Broglie tells us explicitly, "What seemed to me to be eminently desirable was … a return to precise space-time representations, which could give a clear picture of what they were supposed to portray."[17]

W. H. Watson comments on this viewpoint as follows:

> de Broglie knows that experimental physics deals with no figment of the imagination but with the real world in which we live. Physical theory must come to terms with the actualities on which we depend when we investigate nature. Accordingly, de Broglie is not disposed to accept the wave-particle duality without imagining a physical mechanism that can transport an electron, for example, from its source to the place where it is detected.[18]

Watson quotes an admission by L. Rosenfeld of Copenhagen that "young physicists are raising doubts about the correctness of the basic ideas of quantum mechanics," and points out that "The reason... is probably the simple one that they are dissatisfied with these ideas, at least as presented in accordance with current fashion."[19] No more than a very elementary knowledge of human nature is required in order to realize that such a reaction is inevitable. A baffled generation of physicists may renounce the understandability of nature in an "extravagance born of despair," as Schrödinger puts it, but they cannot enforce this renunciation upon the next generation. Alexandre Koyre states this case very clearly:

> Thus I believe that we are entitled to conclude, tentatively, at least, that (i) the positivistic phase of renouncement, or resignation, is only a kind of retreat position, and it is always a temporary one; (ii) although the human mind, in its pursuit of knowledge, repeatedly assumes this attitude, it does not accept it as final–at least it has never done so until now, and (iii) sooner or later it ceases to make a virtue of necessity and congratulates itself on its defeat. Sooner or later it comes back to the allegedly unprofitable, impossible, or meaningless task and tries to find a causal and real explanation of the accepted and established laws.[20]

The present investigation has done just exactly this. Refusing to accept defeat as final, it has "come back to the allegedly unprofitable, impossible, and meaningless task" and has found it profitable, possible, and meaningful. According to the findings of this investigation, nature is just as logical and rational in the far-out regions as it is in the everyday world of our normal experience, and it can be just as understandable if the horizons of theory are extended far enough to encompass those regions that have recently been penetrated by the experimenter and the observer. This is what modern theorists have failed to do. However incredible it may be to those who have been taught from

childhood to regard modern physics–particularly Relativity and the quantum theories–as profound revolutions in scientific thought, it is nevertheless true that the universe which appears in the theories of Einstein, Bohr, and Heisenberg is the same universe for which Newton's Laws were fashioned. The theorist still remains within the old horizons while the man in the laboratory is now exploring the regions beyond the rim.

Modern scientists have added many details, to be sure, and there have been some significant changes in viewpoints, but basically the object of modern scientific study is the same universe that Newton visualized. Whatever modifications have been made have not been in the direction of extending the theoretical horizons, but in the direction of making the theories more "abstract," a currently popular euphemism for "vague." Einstein postulates *relations* between space and time that are altogether foreign to Newton's ideas, and he has deprived the *magnitudes* of these entities of much of the permanence that Newton attributed to them, but nevertheless Einstein's space and time are the same space and time with which Newton worked. The relativist's definition of these entities, his assumption of the "unidirectional, one-valued, one-dimensional character of the time continuum"[21] and his corresponding assumption as to the inherent nature of space would have met with Newton's full approval. Similarly, the quantum theorist has managed to get waves and particles gloriously tangled up, but "wave" and "particle" are concepts from Newton's universe. Heisenberg has turned the thoughts of the atomic physicists into some wholly new channels with his Principle of Uncertainty which asserts, among other things, that a particle cannot have both a specific momentum and a specific position, but here again "momentum" and "position" have the same meaning to Heisenberg that they did to Newton.

In short, modern theories do not pretend to do anything more than generalize the classical theories. Quantum mechanics, says Bohr, "may be regarded as a natural generalization of the classical mechanics."[22] And his comment on Relativity is that "Einstein succeeded in remoulding and generalizing the whole edifice of classical physics."[23] The world of Newton was a world of motion in space and modern physics still treats the universe as a world of motion in space. As Bohr clearly admits, the originators of present-day physical theory cannot even conceive of

anything else. "It lies in the nature of physical observations," he says, "that all experience must ultimately be expressed in terms of classical concepts."[24] The "extension of our range" of which Bridgman speaks are in the experimental realm only. The theorists are still confined within the horizons of Newton, and they are still trying to explain events beyond those horizons by "generalizations" of the classical laws applying to Newton's world. Thoughtful observers have not failed to recognize and comment upon this situation. Bertrand Russell, for instance, has this to say:

> The findings of science had somewhat upset the rigid and closed Newtonian view of the world. But instead of trying to enlarge this view, scientists have on the whole been content to handle their problems with the help of mathematical theories that produce adequate results when suitably interpreted. [25]

Unfortunately, these mathematical theories, or any other theories which do not have the benefit of the "enlarged view" of the universe to which Russell refers simply cannot make the newly discovered physical events understandable, nor can they lead to rational laws which these events will follow. It is inevitable that the harder the physicists try to fit these theories to the facts, the more confused and vague the theories have to be made, and the more convinced the theorists become that "the world is not intrinsically reasonable or understandable."[26]

What the Reciprocal System does, so far as the classical laws are concerned, is not to generalize them, but to delimit their field of applicability. Within these limits, the new system says, the classical laws (with slight modifications in certain cases) are not merely approximations to some more comprehensive and more widely applicable laws, as modern physics considers them, they are complete and accurate representations of the physical facts. Newton's Laws of Motion, for instance, are fully and exactly applicable to all motion in space. But the findings of the present investigation have disclosed that there are changes in physical relations other than motion in space, and where the observed phenomena are due to changes of this nature, partially, as in motion at high velocities, or wholly, as in events at the atomic level, an entirely new set of concepts and laws, related to but distinct from the concepts and laws of classical physics, must be applied. In terms of the preceding discussion, the new system has pushed back the horizons of physical theory to include all types of

changes in physical relationships, not merely motion in space. Once this is done law and order return to the realm of nature, and we are back to a rational universe–not to Newton's universe, but to one which is equally simple and understandable, even though much more extensive.

In the remainder of this volume, together with the preceding volumes in the series, the evidence confirming the statements in the foregoing pages is presented. In most cases the presentation is conclusive in itself. When a positive and unequivocal statement is made, there is no need for any argument to establish that it is positive and unequivocal; when the last page is reached and no *ad hoc* assumption, express or implied, has been encountered, there is no need for any further proof that ad hoc assumptions are not utilized in the work; when all major subdivisions of physical science have been treated in substantial detail, there is no need for argument as to whether the theory is complete and comprehensive; and so on. The crucial issue that does require some consideration is whether the new theoretical system is, as I contend, a true and accurate representation of the physical universe.

Just offhand this would seem to be a clear-cut issue which could quite readily be put to a decisive test, and if we were operating in an intellectual vacuum, so that a decision could be made without reference to past history or to personal preferences and prejudices, this would no doubt be true. But long years of dealing with theories which are not true and accurate representations of the facts have introduced some strange elements into the thought of the scientific profession. *In principle* the situation is clear enough. As expressed by Philipp Frank:

> Among scientists it is taken for granted that a theory "should" be accepted if and only if it is "true", to be true means in this context to be in agreement with the observable facts that can be logically derived from the theory.[27]

If the scientific community actually carried out in practice what Funk tells us in the foregoing statement that they take for granted in principle, there would be no need for this present discussion. Alter the prescribed tests have been made it would be evident that the Reciprocal System is "true" in the scientific sense, whereas the theories with which it disagrees range from hypotheses that are plausible but have little, if any, factual support, or hypotheses which yield correct mathematical results but are unsupported in their

conceptual aspects, all the way down to theories that are openly and seriously in conflict with firmly established facts. But application of this criterion rarely yields unequivocal results in current practice, because, as Frank goes on to say:

> It has never happened that all the conclusions drawn from a theory have agreed with the observable facts… We never have one theory that is in full agreement but several theories that are in partial agreement, and we have to determine the final theory by a compromise.

Thus, while the test of agreement with experience is accepted in principle as something that would apply under ideal conditions, it has in practice fallen into disuse and scientists are at present psychologically unprepared to deal with an innovation, which claims full agreement with observation. When a new theory appears, the possibility of applying the standard criterion directly to determine the validity of the theory is seldom considered, and the question "Is this theory true?" is seldom asked. Instead, the point at issue is regarded as a contest between the new theory and the currently accepted ideas, which that theory seeks to supplant, and the question to be answered is considered to be "Which of these theories is the better?"

In its earlier stages this change in attitude did not involve any significant departure from the policy of basing the evaluation of theories and concepts on their agreement with the facts. What actually took place was that both the new and the old ideas were checked against the facts so far as this was possible, but since each of the rival theories failed to meet one or more of the tests, and science provided no criterion by which to judge the relative weights to be given to the different discrepancies, philosophical or other outside considerations were called upon to furnish such criteria. During this era philosophy, science and common sense were regarded as compatible and harmonious, on the whole. Indeed, physics was identified as "natural philosophy" and one of the most popular definitions of science in general characterized it as "organized common sense."

Recent developments in science have altered this situation very drastically. Modern physical science has arrived at many conclusions which, in the words of Tolman, are "in direct opposition to the requirements of so-called common sense"[28] and which are almost equally objectionable from the viewpoint of philosophy. Since the

scientists realize that they are highly vulnerable to criticisms based on philosophical grounds and still more vulnerable to criticism based on common sense, they have been able to defend their positions only by denying the applicability of philosophical and common sense principles to scientific matters. Without any common ground on which to meet, arguments over these debatable issues have become highly partisan conflicts in which scientists are arrayed against non-scientists. In the process of closing ranks for the defense of scientific conclusions against the attackers from the outside, there has been a tendency to lose sight of the valid scientific to the currently accepted conclusions and, in effect, to make conformity with the orthodox views a test of loyalty to the profession. Even the most eminent scientists have not been exempt. It is well known that Einstein was practically relegated to the sidelines during his later years because of his unwillingness to concur in some of the generally held viewpoints, and Louis de Broglie speaks quite frankly of abandoning his attempts to reconcile wave mechanics with "traditional physics and the idea of causality" because of "the hostility they elicited from other theoretical physicists."[29]

A natural but unfortunate result of this identification of the currently accepted theories with professional solidarity has been that the theories which are the weakest, and have therefore been subjected to the most frequent and most violent attacks are the most jealously guarded and most strongly defended against criticism of any nature, scientific or otherwise. These cherished products of modern ingenuity are in conflict with the facts of observation and experiment at many points, and if the number and seriousness of these conflicts were to be accepted as a criterion of the lack of validity of these theories, in accordance with previous scientific practice, the theories would have to be relegated to the status of unproved and improbable hypotheses. "How long would the great physical theories of the past have lasted were they riddled with formal inelegancies and inconsistencies of the sort embodied in both renormalized and unrenormalized quantum theory?", asks Norwood R. Hanson, and he gives us his judgment: "Not very long, I submit."[30] Hence, in order to preserve the position of preeminence into which these theories have been elevated, present-day physicists have repudiated the concept of scientific "truth," defined as agreement with experience, and have substituted a most unusual concept, tailor-made to reinforce the defense of their embattled

theories. To get a good view of this remarkable new concept, let us consider the following statements:

> Nor can a theory be true or false; it is in any case relevant to a highly selected group of data—usually with the recalcitrant ones ignored. (McVittie)[31].

> We do not speak of theories and postulates as probable or improbable, but as correct or incorrect relative to a given state of scientific knowledge, or perhaps as approximations to a more exacting theory either known or not yet known. (Margenau)[32]

> The relativist dissolves the concept of truth by teaching that what is "true" depends on the point of view of the subject. (don Weizsäcker and Juilfs)[33]

All of these authors are taking the stand that the existing situation requires accepting theories as "correct" even though they cannot qualify as scientifically "true." This, of course, accomplishes the desired purpose simply and neatly. No matter how many discrepancies between theory and experience may prevent one of these ingenious modern products from being classified as scientifically "true," it is accepted doctrine and hence it is "correct" by virtue of a definition, which equates correctness with general acceptance. The existing "state of scientific knowledge" is the sum total of currently accepted ideas, and since the theory under consideration is one of these ideas, it is automatically "correct relative to the existing state of scientific knowledge."

But when this definition of "correct" is substituted for that which is scientifically "true," then there is no longer any criterion by which the true theory can be recognized when and if it appears. Since this true theory necessarily differs from existing doctrine, it is, by definition, "incorrect," and has no different standing than a theory, which is wholly at odds with the facts. What this doctrine actually does is to put the stamp of official approval on the widespread inclination to accord nothing but a summary dismissal to any new idea which offers any significant challenge to accepted habits of thought. It is particularly disconcerting to the originator of a new theoretical structure such as the Reciprocal System which is prepared to meet the requirement of full agreement with experience–the requirement that is, in principle, supposed to establish it as "true" in the scientific sense–only to find that this criterion has been replaced by the requirement of being "correct

relative to the present state of scientific knowledge": a requirement that the new system cannot meet simply because it represents an advance in the state of scientific knowledge.

"But why, after all, should scientific truth be a static concept?" asks Margenau.[34] The situation which now confronts the new system being discussed in this volume shows why. If truth is not a static concept then we have no adequate means by which to evaluate progress toward that truth, or toward that "more exacting theory" to which Margenau refers. The whole effect of the change that has been made in the "official" criteria in recent times is to substitute conformity to accepted doctrine for the degree of approximation to the truth as the test to be applied to new ideas, and to make general acceptance virtually the equivalent of proof.

Feyerabend has subjected this modern practice to a very penetrating criticism. He points out that the refusal to admit any new theories unless they "either contain the theories already used in this domain, or are at least consistent with them inside the domain" does not eliminate a theory "because it is in disagreement with the facts; it eliminates it because it is in disagreement with another theory, with a theory, moreover, whose confirming instances it shares. It thereby makes the as yet untested part of that theory a measure of validity."[35]

This present volume is not a treatise on scientific methods and procedures, but the particular policies of present-day science that have been discussed in the preceding pages constitute a serious obstacle to an accurate evaluation of the theoretical structure that is being presented herein. It is therefore not only appropriate but essential to bring out the true nature of these policies, so that the reader who finds the conclusions of this work at variance with some of the assertions of Relativity, or the quantum theories, or some other segment of so-called "modern physics" will realize that these theories do not even claim to be true; when we penetrate the "fog" which, as de Broglie says, surrounds them, we find that they are merely "correct relative to the existing state of scientific knowledge": a state defined by Relativity, quantum theory, etc., and they make no pretense of being in full agreement with the facts of experience. At the very most, all that they can legitimately claim is some sort of an interim status. As Dirac summarizes the situation:

> The present stage of physical theory is merely a steppingstone toward the better stages we shall have in the future. One can be quite sure that there will be better stages simply because of the difficulties that occur in the physics of today.[4]

There is, of course, ample justification for using incomplete and incorrect theories for whatever purposes they may serve, pending the development of something better, as long as scientists do not succumb to the ever-present temptation of elevating these theories to the status of established facts simply because they are the best instruments of thought currently at hand. If the real status of such theories—"stepping-stones," stopgaps, or whatever we may call them—is kept in mind they will not stand in the way of new developments. Hanson expresses the true scientific viewpoint in a comment on a statement by another scientist in which quantum theory was characterized as "uniformly successful." Although himself a strong supporter of the Copenhagen doctrine, Hanson points out that this flattering description is far from correct; that, in fact, "quantum theory is conceptually imperfect" and "very far from being uniformly successful," but that he and his colleagues are standing behind it because it is "the only extant theory capable of dealing seriously with microphenomena." He then goes on to say:

> One must distinguish those moments in the history of physics when two equally well-developed theories have competed to furnish the "best" explanation of a phenomenon from those quite different periods during which scientists have available to them but one workable theory *without even an intelligible alternative anywhere nearby.* Such is the present state of quantum theory.[30]

It is in order to suggest that we have now arrived at another of those "moments in the history of physics" when there are two well-developed theories available. As matters now stand, the Reciprocal System cannot claim to have gone into the *mathematical* details of *some* physical processes as extensively as quantum theory. On the other hand, it has done much more in *other* mathematical areas that quantum theory purports to cover—for instance, there is nothing in quantum theory that is at all comparable to the inter-atomic distance expression derived from the postulates of the new system–and it has developed the conceptual aspects of *all* of these processes to a degree that is far in advance of the bare minimum that quantum theory offers. And, of course, quantum theory cannot compete at all from the

standpoint of the extent of coverage. At best, it is a theory applicable to a limited portion of the universe, whereas the Reciprocal System is a theoretical structure applicable to the entire universe. Furthermore, the future outlook is much more favorable for the new system. An immense amount of scientific time and effort has already been applied to the development of the quantum ideas over many decades, and the limitations to which quantum theory is now subject are those of a full-grown conceptual scheme, essentially permanent, barring some radical change in the foundations of the theory. On the other hand, the limits of the present development of the Reciprocal System simply reflect the comparatively minuscule amount of time that has thus far been applied to this development, and there is a wide open field for future extension of the application of the new system.

CHAPTER II

Where We Stand: Conceptually

A major factor in the advance of physical science from its primitive beginnings to its present position has been the availability of mathematical techniques to aid in the acquisition of knowledge and to facilitate the systematization and utilization of that knowledge after it has once been acquired. The practical advantages of having a substantial portion of the accumulated knowledge in any physical field available in a form suitable for mathematical manipulation and easy adaptation to the specific problems at hand are familiar to all concerned and need no particular comment. Equally important to the investigator is the conceptual freedom, which is attained by the use of mathematical rather than verbal reasoning. The answer to a problem of long standing in the physical field usually involves some significant change in the basic concepts entering into the phenomena with which the problem is concerned, but the ability of the human mind to break loose from the shackles of traditional thought and formulate totally new concepts is severely limited, and finding the solution to a problem of this kind by direct means is extremely difficult.

If the problem is attacked mathematically, however, the investigator has much more freedom. He is still circumscribed by the limits of current thinking with respect to the definitions of his terms and other general concepts entering into his mathematical expressions, but from there on he is essentially free of restraint. If a direct function fails to serve his purpose, he is entirely at liberty to try an inverse function; if a trigonometric relationship proves to be inapplicable, he is free to try a logarithmic relation, and so on, even though the conceptual changes involved in these modifications of the mathematical relationships are so drastic that they would be essentially inconceivable from the standpoint of a direct conceptual approach. Because of this freedom of maneuver, it is often possible to obtain a mathematical solution for the problem under investigation and to embody this solution in an equation or some other

mathematical expression. With this mathematical knowledge at hand, the investigator may then be able to go back to the physical meaning of the mathematical terms and make the conceptual jump that was not possible without the guideposts established by the mathematical study.

Max Planck's discovery of the quantum of radiant energy is a classic example of an investigation that followed such a pattern. The reason for the observed distribution of spectral frequencies in blackbody radiation had long been an unsolved problem. Mathematical expressions formulated by Wienand Rayleigh on the basis of different ideas as to the mechanism of the radiation were each successful in certain spectral regions but failed in others. Planck addressed himself to this problem, and after a long search succeeded in constructing a new expression which correctly represented the distribution of frequencies through the entire range. As soon as he obtained this expression–"on the very day when I formulated this Law," he tells us–he undertook the "task of investing it with a true physical meaning,"[36] and in this way he ultimately conceived the idea of the quantum. Theoretically, of course, someone could have hit upon this idea directly, without the benefit of the prior knowledge of the mathematical relationship, but the concept of discrete units of energy was so foreign to current scientific thought that scientists were simply unable to visualize this possibility until Planck was pushed into making the conceptual adjustment as a matter of sheer mathematical necessity.

Much the same thing took place in this present investigation. The concept of a reciprocal relation between space and time, the central idea of the new theoretical system, could have been formulated directly—indeed, it will be shown in a subsequent chapter that if the question of the basic structure of the physical universe is examined in a cold-blooded, logical and systematic manner, without making any unsupported assumptions in advance, the formulation of such a concept is inevitable—but, like the quantum, it represents such a radical alteration of existing thought that the human mind was simply unable to make the direct jump. Here again, what could not be done directly was done indirectly by way of the mathematical approach. An intensive study of a number of physical phenomena in the first phase of the project produced some new and more accurate mathematical expressions for the variability of these phenomena under different conditions. Attention was then turned to finding a physical explanation for each of these expressions, and after a long search, the reciprocal postulate finally emerged.

There is no guarantee; however, that the search for a physical explanation of a mathematical relation will always be as successful as it was in the two instances that have been discussed. Even though mathematical information is very helpful, it is still only a clue, not a map or a blueprint, and the conceptual innovation that is necessary for a complete and correct explanation may still elude the investigator. In many important studies, some of which have a bearing on the subject matter of this volume and will therefore be discussed in the next chapter, the investigations have produced conceptual answers that are unable to meet the requirements for proof of their validity, and hence are wrong or, at least, only partially correct. In many other cases, the problem has been still more recalcitrant, and the most strenuous efforts have failed to produce any plausible explanation of the mathematical results.

From a strictly logical point of view it seems rather obvious that the existence of these correct but unexplained mathematical expressions of physical phenomena is an indication that the work of the scientist is still incomplete, and that more time, effort, and ingenuity will have to be applied to these problems. But this appraisal of the situation is- very distasteful to a profession that, at the moment, is basking in the sunlight of an impressive record of successes, and in order to avoid the necessity of admitting failure in these instances, the physicists are now denying that these problems exist, and ate advancing the curious contention that the mathematical expressions are complete in themselves and that further explanation is not only unnecessary, but actually non-existent. As expressed by Northrop, they are "trying valiantly to convince themselves that their present collection of mathematical formulae, which possess no physical meaning, constitute an ideal state of affairs."[37]

Even though this doctrine is devoid of any logical foundation and is obviously a rationalization of failure that belongs in the "sour grapes" category, it is tremendously popular because it emancipates the theorist from the harsh necessity of conforming to physical reality. The typical present-day contribution to physical theory consists of a rigorous mathematical "calculus" which is, in the words of Rudolf Carnap, "constructed floating in the air, so to speak," and which deals with terms whose meaning, if any, is vague and indefinite. "The words may have independent meaning," says Braithwaite, "but this is not how the words are used in a treatise on physics. There they are

used as symbols in a calculus which is to be interpreted as an applied deductive system; they are not understood as having any meaning apart from their place in such a calculus."[38]

The popularity of this method of procedure is easy to understand. If the theorists were required to make all of their terms meaningful and to expose their work to comparison with the observed facts at every step of the way, the pages of the *Physical Review* and similar journals would shrink drastically. Genuine additions to theoretical knowledge are not nearly so easy to produce, as the present volume of published material would seem to indicate.

It is not the prerogative of the author of this work to say how anyone else should conduct his investigations, nor what kind of material should be published in the scientific journals, but the prevalence of this abstract mathematical approach to physical theory has created a rather general impression that this is the only proper way to carry out such activities and that any work which does not follow the present-day "standard procedure" of mathematical formulation in terms of tensors, or spinors, or matrix algebra, or some other complex mathematical device, is automatically devoid of merit. This attitude very definitely is an appropriate subject for comment, as one of the most important conclusions reached in the initial phase of this present investigation was that while mathematical techniques are valuable tools for certain purposes, as mentioned earlier, the present-day "standard procedure" utilizing mathematical processes with little or no actual physical meaning is inherently incapable of remedying the existing deficiencies in physical theory, and a procedure more definitely tied down to physical reality and emphasizing the conceptual rather than the mathematical aspects of the theoretical situation is essential to the attainment of the objectives of a work of this kind. Development of the Reciprocal System has therefore followed a pattern altogether different from that of the typical present day approach.

In this development all terms and concepts are sharply and explicitly defined, and all of the conclusions that are reached—the intermediate as well as the final results—are capable of being verified by comparison with the findings of observation and measurement, to the extent that observational knowledge is available. There has been no deliberate attempt to minimize the use of mathematics, but the findings of this work show that the complex entities and phenomena of the universe are built

up from simple foundations and these simple basic phenomena and relations do not require complex mathematics for their representation. The *correct* mathematical representation of a simple physical relation must itself be simple. There are many complex phenomena in the universe, to be sure, but the initial presentation of the Reciprocal System, in this and the books previously published, does not reach the point in the theoretical development where any substantial degree of complexity has emerged, and as a consequence, the mathematical treatment, while entirely adequate for its purpose, is very simple—so simple, in fact, that to the modern physicist, accustomed to page after page of mathematical symbolism with only the bare essentials of a verbal commentary, the work seems to be wholly non-mathematical.

It is rather ironic that such a judgment should be passed on the first general physical theory which carries out a complete quantitative development coincidentally with the qualitative development and which, for the first time, permits physical magnitudes to be calculated directly from purely theoretical foundations without the aid of "constants" obtained by measurement. Nevertheless, this tendency to classify the work as non-mathematical would be of no particular consequence and would not call for any special comment, were it not for the further tendency on the part of the physicists to regard the adjective "non-mathematical" as synonymous with "defective" or "unacceptable," and to adhere to what Northrop calls "the scientific dogma that nothing is truly scientific which is not mathematical." [39]

The general attitude is clearly expressed by a European reviewer who repeats the major conclusions of *Beyond Newton* and then comments in a caustic manner that the author "arrives at these revolutionary conclusions without recourse to mathematics, and by the sole magic of words." This attitude has been encountered so frequently that an effort has been made to deal with it in each of the preceding books in this series, but apparently something more detailed and more emphatic is needed, and before proceeding with the principal business of this chapter–a review of our conceptual knowledge of space and time–it seems advisable to discuss the distinction between conceptual and mathematical knowledge, and to bring out the point that it is truly the "magic of words" that invests the results of any work, mathematical or otherwise, with a meaning.

The findings of this investigation are that the difficulties which are being experienced by present-day physical science are not due to

any lack of full mathematical treatment—we now have mathematics running out of our ears—nor to inadequacy of the mathematical tools available—mathematical methods have reached a peak of sophistication and complexity far beyond the needs of basic science—nor to the employment of faulty logic in the development of theory—many of the conclusions of modern physics are illogical, to be sure, but it is quite obvious that these are errors of desperation born of long years of frustration; they are not the cause of the existing difficulties but the result of them. The root of the present trouble is *conceptual*. The elaborate and versatile machinery of modern science has been unable to solve the more difficult problems of the universe of space, time, matter, electricity, and so on, simply because all of its efforts have been based on erroneous assumptions as to the nature of these entities—space, time, matter, electricity, etc.—with which it is dealing.

In large measure, this is a result of a misconception on the part of the physicists as to the degree of latitude that they are privileged to exercise in the construction of theory. Present-day theorists are under the impression that they are at liberty to define the concepts, which they use in any way that they see, fit. Herbert Dingle, for instance, tells us that atoms, as the physicist conceives them, are "creatures of the imagination, to be formed into the image of our fancies and restricted by whatever laws we cared to prescribe, provided only that when they behaved in accordance with those laws they should produce phenomena."[40] Einstein's attitude toward basic concepts was similar. "The axiomatic basis of theoretical physics … must be free invention,"[41] he insists.

The weakness of this policy is that when conclusions are reached on the basis of such concepts, they too belong to the world of fancy, not to the world of reality. If the theoretical physicist entered into his activities merely as a mental exercise, in the manner of some of the more abstruse mathematical developments, no exception could be taken to his procedure, but as matters now stand, the theorist who is working with "creatures of the imagination" sooner or later shifts his ground and starts claiming that his conclusions are applicable to the real world. Thus we find the Copenhagen school of physicists, principal architects of the present-day "official" atomic theory, asserting that the particles of which their "atom" is constructed are not "material particles in space and time" and do not "exist objectively."[42] As a statement about the dream world of the physicists' imagination, this may well be correct.

But the Copenhagen theorists are not content to look at it in this light; they want to apply it to the real physical world and to real physical atoms, and here it has no relevance at all, because the entire theoretical development which leads to these strange conclusions has been based on a concept of atomic structure "formed in the image of their fancies" and not on a concept of the atom as it actually exists physically.

The Copenhagen model of the atom is essentially the same kind of a thing as the "billiard ball" model postulated by an earlier generation of scientists. Both models were devised to represent certain aspects of the behavior of atoms, ignoring all other aspects, and both have had a considerable degree of success in these particular areas. But neither is in any way a picture of the real physical atom, and whatever conclusions are drawn from either model are conclusions about the model, not about the physical atom. If we want to arrive at conclusions applicable to the real physical atom, then we must start with concepts, which *accurately* represent the physical atom and its properties; we have no latitude for error.

It is true that the formulation of such concepts is a formidable undertaking. The theorists work under a severe handicap because of the lack of any direct method of ascertaining the true nature and properties of the physical atom, and they have turned to speculation and assumption as a matter of necessity, or presumed necessity. But even if speculation is unavoidable, this does not make the results thereof any less speculative. If these results can be tested against the facts of observation and pass this test successfully, then the speculation has paid dividends, but if they fail in the test or if they are untestable conclusions of such an absurd character as the Copenhagen contention that physical aggregates which *do* exist objectively are composed of parts that *do not* exist objectively, it is evident that the speculation has missed its mark and that the conclusions apply only to the speculative world of fancy, not to the real world.

In cases such as this the lack of logic in the theorists' position is obvious, and it is surprising that so few critics have protested (publicly, at least) the way they are "getting away with murder." But there are many other instances in which no one seems to have realized that the concepts upon which a particular physical theory is based may not coincide with the actual physical realities, which these concepts are, intended to represent. The concept of time, for example, is rather

vaguely defined in present-day theory, but all definitions are specific and in agreement in one respect; that is, the magnitude of a time interval can be measured by means of a suitable clock. We actually have no assurance, however, that the quantity thus defined and measured always coincides with the physical time that enters into such relations as velocity. Modern theory assumes such a coincidence, but it will be shown in the subsequent pages that this assumption is frequently incorrect and the time measured by means of a clock often is *not* the true physical time applicable to the phenomenon under consideration.

The consequences of an inadvertent error of this kind in the definition of a concept are just as serious as those resulting from a wild speculation that misses its mark, and one of the most essential tasks of the present investigation has therefore been to examine the basic concepts of space, time and motion carefully and critically to make certain, as far as it is possible to do so, that the way in which these concepts are defined for purposes of the development of theory conforms to the nature and properties of the physical entities which these concepts are intended to represent. Our first concern will be to ascertain just how much *actual knowledge* about these entities is available. In this chapter we will examine the available conceptual knowledge.

The term "conceptual knowledge" as used in this work, refers to any information that has a specific meaning and that applies specifically to definable physical concepts. These concepts may be "real" physical objects, in the sense in which this term is commonly used, or they may be abstractions such as "force," the real existence of which is debatable. The essential requirement is that they be capable of explicit definition, so that we know what we are talking about. Some items of conceptual knowledge can be expressed in mathematical terms, and here we have both conceptual and mathematical knowledge, but it does not necessarily follow that all mathematical expressions represent conceptual knowledge.

To illustrate this point, let us consider the structure of some chemical element, sodium, for example. Modern theory tells us that the sodium atom contains 11 extra-nuclear electrons. If this statement could be substantiated, it would constitute conceptual knowledge, as herein defined: authentic information about a specific physical concept, the sodium atom. But when we examine this alleged information carefully, we find that what is actually known is that there are certain

mathematical expressions of physical relationships—Moseley's Law, for instance—in which each kind of atom has its own characteristic numerical value, and the value applicable to sodium is 11. The conclusion that this indicates the existence of 11 units of some kind in the sodium atom is reasonable, but it is no more than an assumption, and the further conclusion that these units are electrons has no factual foundation at all. It is purely an *interpretation* of the mathematical relations in the light of current ideas as to the nature of the atomic structure. This closer scrutiny thus discloses that all we have here is *mathematical* knowledge; the currently favored interpretation of the mathematical relation could very well be wrong (and this present investigation indicates that it is, indeed, wrong).

This example illustrates the fact that mathematical knowledge is, in general, incomplete and non-specific knowledge. In this particular case, all that the mathematics are able to tell us is that there are 11 units of *some kind* that are in *some way* connected with sodium. The mathematical equations give us no indication as to the nature of the units nor as to the nature of their connection with the sodium atom. The number 11 is dimensionless in the equations and it can refer to any kind of a unit, without restriction. In order to carry knowledge of the mathematical type to completion we must resort to words; we must find names for the mathematical terms, which will give these terms their correct physical meanings.

The need for verbal additions to transform mathematical knowledge into complete knowledge is not applicable in reverse; that is, conceptual knowledge expressed verbally can be complete in itself without any necessity for mathematical addition or elaboration. Qualitative information, which is by definition outside the scope of mathematical treatment, constitutes a very important part of the accumulated store of scientific knowledge. Furthermore, whatever can be expressed in mathematical symbols can also be expressed in words. The verbal expression may be complicated and awkward, but if a mathematical expression has a physical meaning, then it must be possible to state the same thing in words, because it is only through the medium of words that we give meaning to symbols. For instance, we can write $PV = k$. In itself, this means nothing. But if we define these four symbols in an appropriate manner and add some necessary qualifications as to the circumstances under which the equation is

valid, a "text," as Bridgman calls such an explanation, this expression becomes Boyle's Law, one of the important relations of physics. When we have thus given the mathematical symbols definite meanings, it then becomes possible to reproduce the meaning of the equation in words alone, and the elementary physics textbooks customarily state Boyle's Law and similar physical principles both ways.

The current tendency to magnify the importance of complex mathematical treatment and to deride and ridicule any development utilizing purely verbal logic or simple mathematics, "the false worshipful attitude toward mathematics,"[43] as Northrop calls it, is a completely upside down attitude. Mathematics is not essential to thought, nor is it a substitute for thought. As Freeman J. Dyson warns, "Mathematical intuition is dangerous, because many situations in science demand for their understanding not the evasion of thought, but thought."[44] The policy that has been followed throughout this work is to utilize mathematics where and to the extent that a useful purpose is served, and not otherwise. Where no mathematical treatment has been required, none has been used. Where arithmetic or simple algebra are adequate for the tasks at hand, these are the tools that have been utilized. Where it has been necessary or convenient to call upon the calculus or other advanced mathematical devices, this has been done. The mathematical simplicity of the work does not indicate any lack of mathematical accuracy, nor is it the result of any non-mathematical attitude on the part of the author. It merely reflects the simplicity of the basic physical concepts and relations as they emerge from the development of the consequences of the postulates of the new system.

An additional factor tending to minimize the mathematical content of this particular volume is that in the normal processes of human thought the answer to the question "What?" precedes the answers to the questions "How many?" and "How much?" If we are asked to explain the operation of an automobile, for example, we first describe the functions of the various parts in purely qualitative terms, and if we find it necessary later on to introduce mathematical relationships such as compression ratio, torque, efficiency, etc., we do so only after a full qualitative explanation has been given. Even though this present work is addressed primarily to individuals who are well versed in the general subject matter of physical science, it is an elementary presentation of the new theoretical system, comparable to the first explanation of the

principles of automobile operation, and like the latter it is mainly a qualitative explanation.

The primary advantage of utilizing mathematical methods where they are applicable is the convenience of employing a few symbols to represent concepts and operations that would require a great many words for verbal definition. In the process of theory construction there is a further gain in that once the symbols have been properly defined to begin with, these definitions can be laid aside and the analysis can proceed in the symbolic and abstract language of mathematics until the final conclusions are reached, when the definitions are again called upon as a means of ascertaining the meaning of the symbols that represent these conclusions. This procedure not only expedites the intermediate operations very materially, but also enables these operations to be carried out with the freedom from the conceptual limitations of human thinking that has already been mentioned as one of the most important characteristics of the mathematical approach to physical problems.

Unfortunately freedom, once attained, is often abused, and so it has been in present-day physics. The justification for ignoring the meaning of the symbols in all of the intermediate mathematical steps between the initial premise and the final conclusion is that whatever meaning is assigned initially remains unchanged throughout the subsequent manipulation and hence does not require any further consideration until the final conclusions are ready for interpretation. On this basis every intermediate step has just as definite and specific a meaning as the initial and final statements, and the customary practice of handling these intermediate steps in terms of symbols only is merely a matter of convenience, not a matter of necessity. However as pointed out by Braithwaite in the statement previously quoted modern physical science is following an altogether different procedure, utilizing terms which are *never* specifically defined and which have no "independent meaning"; that is, no meaning aside from the way in which they enter into the mathematical development. "The possibility of explicit definitions," says Hesse, "is not generally one of the considerations which weigh with scientists in judging a good theory."[45] One of the major virtues of mathematical treatment in general is the precision with which mathematical statements can be made, but in present-day physics mathematical methods are deliberately employed for the opposite purpose: to make theories more "abstract"; that is, more vague.

As Whittaker comments, "the mathematical physicist... is interested in non-commutative symbolism for a wholly different reason. He may be said to be, in a certain sense, moving away from precision."[46]

Scientific history shows that physical problems of long standing are usually the result of errors in the prevailing basic concepts, and that significant conceptual modifications are a prerequisite for their solution. But the effect of the new mathematical practices of the theoretical physicist is to freeze the existing basic concepts and to secure some sort of agreement with observation by making the mathematical treatment more complex and its conceptual meaning more vague, rather than locating and correcting the error in the conceptual foundations upon which the mathematical treatment is based. Instead of definite answers to our problems, what we get is a profusion of "mathematical theories which are being continually formulated at an ever-accelerating tempo and in a complexity and abstractness increasingly formidable… These have come crowding on each other's heels with ever-increasing unmannerliness, until the average physicist, for whom I venture to speak, flounders in bewilderment." (P. W. Bridgman).[47]

In effect, the modern scientist is taking the stand that his mathematical techniques are so powerful that they can overcome whatever handicaps may be imposed by errors in the basic physical concepts. The present work challenges this assumption, and contends that valid, meaningful, and *physically correct* basic concepts are primary requisites for sound theory, and that a logical development of these concepts is the essential element in constructing the framework of such a theory. On this basis, conceptual knowledge is of paramount importance, and it will therefore be our first concern as we now begin a survey of our present knowledge of space and time.

It has become increasingly clear in recent years that the area in which we make direct contact with space and time is only a very small sector of the universe as a whole. It does not necessarily follow, therefore, that the properties, which these basic entities possess, or seem, to possess, in the limited area subject to our direct observation are properties of space and time in general. Nevertheless, the information, which we obtain by direct observation, is the cornerstone of any scientific consideration of the space-time situation, and it is therefore extremely important to be certain just what our observations *do* tell us about the properties of space and time.

In view of the meticulous — even hair-splitting — attention that science pays to details in the subsequent stages of development of theory, the casual way in which the basic fundamentals are treated in present-day physical science is a curious phenomenon. Certainly the items that lie at the very base of the structure of physical theory and therefore have a material bearing on the validity of every part of the whole should have no *less* careful and critical scrutiny than the various elements of the superstructure, but the prevailing opinion appears to be that it is sufficient to accept, "without examination," as Tolman[21] puts it, the superficial impressions of the lay public as adequate definitions of space and time for scientific purposes.

There even seems to be an impression that the validity of the basic concepts is immaterial, and that accuracy can be introduced later in the development. For instance, R. B. Lindsay tells us that "a physical theory starts with primitive, undefined concepts, such as the notions of space and time. It proceeds to the construction of more precisely defined constructs, for instance, mass and force in mechanics."[48] This casual attitude toward conceptual foundations is not only highly incongruous in a profession that prides itself on the "rigor" of its treatment of the subject matter within its field, but it is also entirely unrealistic. Derived concepts cannot be more precisely defined than their antecedents. Whatever uncertainties may exist in the definition of space are carried along undiminished to the concept of force, since force is defined in terms of mass and space.

Furthermore, there is no such thing as building theories on "undefined concepts." If a concept is not explicitly defined, it is implicitly defined by the way in which it is used. Concepts may be vaguely defined, as in much of present-day theory, poorly defined, or erroneously defined, but they cannot be undefined. In the case of space and time it is merely assumed that the definitions are so well known and so universally accepted that no further discussion is required. One current physics textbook, for instance, simply says "Time intervals are measured by clocks, with which everyone is familiar," and it then proceeds to insert the time terms into all manner of physical relations without further ado. Newton did essentially the same thing, explaining, "I do not define time, space, place, and motion, as being well known to all."

But no structure is any stronger than its foundations, and one of the most essential tasks of the present investigation has been to make a detailed study of space and time as they appear under direct *observation,*

with the objectives of determining first, whether the conclusions as to their properties that are commonly drawn from these observations are justified, and second, whether any information that can legitimately be derived from observation has been overlooked. The remainder of this chapter will be concerned with the results of that study.

The most conspicuous property of space as we know it first hand is that it is *three-dimensional.* Of course there is much imaginative speculation about a fourth dimension, and mathematicians are fond of constructing hypothetical spaces of n dimensions, but the sector of the universe which we inhabit very definitely presents a three-dimensional aspect to our observation—no more, no less.

Additionally, space, as we find it, is *homogeneous*; that is, so far as we can tell, each unit is exactly like every other unit, and it is *isotropic*, that is, its behavior is the same in all directions. Here again there are many speculations and hypotheses, which involve directional characteristics or departures from homogeneity, but there is no direct evidence of anything of this kind, and we are now considering only the properties of space as they appear under direct observation.

When we have come this far we have exhausted the information that we can obtain directly. Space is three-dimensional, homogeneous and isotropic in our local environment, and that is all that we can tell from direct observation. It is frequently claimed that these properties necessarily call for the existence of certain other properties; for instance, that "infinity and mathematical continuity (infinite divisibility) follow directly from its homogeneity."[49] But even if there were general agreement on these points—which there is not—such properties are not directly observable. If there is a limit to the divisibility of space, it is below the present observational range, and certainly we cannot verify the existence of infinite space.

Little as we know about space, our direct knowledge of time is still more limited. Even those few items that are accepted as factual are largely assumptions. As Eddington states the case:

> We have jumped to certain conclusions about time and have come to regard them almost as axiomatic, although they are not really justified by anything in our immediate perception of time.[50]

The most conspicuous feature of time as we observe it is that, in some way, it progresses. In fact, it is only as a progression that we know it at all; whatever properties we can recognize in time are simply

the characteristics of the progression. We note, for one thing that the progression is uniform, so far as we can determine. Another fact that we observe is that in the context of the familiar phenomena of our everyday life, time is scalar. In the velocity equation v = s/t for example, the term t is a scalar quantity. We also observe that time appears to move steadily onward in the *same* scalar direction and we have formulated the Second Law of Thermodynamics to give expression to this empirical observation. Many physicists are therefore inclined to believe that we know time to be *unidirectional*, and in the statement previously mentioned, Tolman lists this as one of the properties of time which he "assumes without examination." Other observers, notably Eddington, have pointed out that there is a serious question as to the validity of this conclusion because, notwithstanding the assertion contained in the Second Law, the term t is *mathematically reversible* in the equations representing the various physical phenomena. In spite of the constant direction of "Time's arrow" in our local region, it is thus clear that we will have to be cautious about extrapolating the constancy of direction to the universe as a whole.

So far our reexamination of the observed properties of space and time has produced no surprises, but we have now arrived at a place where the lack of a careful and critical study of this kind has caused physical science to fall into a serious error that has had unfortunate consequences in many areas of physical theory. As has been mentioned, time enters into the mathematics of the physical processes with which we are most intimately concerned as a scalar quantity. From this the physicists have jumped to the conclusion that time is one-dimensional, and this conclusion, another of those accepted "without examination" by Tolman, is now, as Eddington put it, regarded "almost as axiomatic." Čapek explains:

> The basic relation in space is juxtaposition; the basic relation in time is succession. The points of space are beside one another; the instants of time *follow* one another.[51]

Notwithstanding its general and unquestioning acceptance, this conclusion is entirely unjustified. The point that the physicists have overlooked is that "direction" in the context of the physical processes, which are represented by vectorial equations in present-day physics always, means "direction in space." In the equation v = s/t, for example, the displacement s is a vector quantity because it has a direction *in*

space. It follows that the velocity v also has a direction *in space,* and thus what we have here is a *space velocity equation.* In this equation the term t is necessarily scalar *because it has no direction in space.*

It is quite true that this result would automatically follow if time were one-dimensional, but the one-dimensionality is by no means a necessary condition. Quite the contrary, time is scalar in this space velocity equation (and in all of the other familiar vectorial equations of modern physics: equations that are vectorial because they involve direction in space) *irrespective of its dimensions,* because no matter how many dimensions it may have, time has no direction in space. If time is multi-dimensional, then it has a property that corresponds to the spatial property that we call "direction." But whatever we may call this temporal property, whether we call it "direction in time" or give it some altogether different name, it is a temporal property, not a spatial property, and it does not give time magnitudes any direction in space. Regardless of its dimensions, time cannot be a vector quantity in any equation such as those of present-day physics in which the property, which qualifies a quantity as vectorial, is that of having a direction in space.

The existing confusion in this area is no doubt due, at least in part, to the fact that the terms "dimension" and "dimensional" are currently used with two different meanings. We speak of space as three-dimensional and we also speak of a cube as three-dimensional. In the first expression we mean that space has a certain property that we designate as dimensionality, and that the magnitude applying to this property is three. In other words, our statement means that there are three dimensions *of* space. But when we say that a cube is three-dimensional, the significance of the statement is quite different. Here we do not mean that there are three dimensions of "cubism," or whatever we may call it; we mean that the cube exists in space and extends into three dimensions of that space.

There is a rather general tendency to interpret any postulate of multi-dimensional time in this latter significance; that is, to take it as meaning that *time* extends into n dimensions of *space*, or some kind of a quasi-space. But this is a concept, which makes little sense under any conditions, and it certainly is not the meaning of the term "multi-dimensional time" as used in this work. When we here speak of time as three-dimensional, as we will later in the discussion, we will be employing the term in the same significance as when we speak of space

as three-dimensional; that is, we mean that time has a property which we call dimensionality, and the magnitude of this property is three. Here again we mean that there are three dimensions of the property in question: three dimensions *of time*.

There is nothing in the role which time plays in the equations of motion to indicate specifically that time has more than one dimension. But a careful consideration along the lines indicated in the foregoing paragraphs does show that the present-day assumption that we *know* time to be one-dimensional is completely unfounded, and it leaves the door wide open to establishing the true dimensions of time by other means. Errors such as this masquerading as established facts are among the most serious obstacles to the advance of knowledge, and unmasking an error of this kind is often the key to solution of a problem of long standing.

Although the items that have been discussed in the preceding paragraphs constitute all that we actually know about space and time individually from direct observation, there is one more source of direct information, as we have some observational knowledge of the *relation* between space and time. What we know is (1) that the relation between space and time in the sector of the universe accessible to direct observation is motion, and (2) that in motion space and time are reciprocally related from a scalar standpoint; that is, moving a greater distance in the same time has exactly the same effect on the speed, the scalar measure of the motion, as moving the same distance in less time.

We may now summarize the primary subject matter of this chapter, the conceptual knowledge of space and time that we have been able to obtain from direct observation of these entities as they exist in our local environment:

> *Space* is three-dimensional, homogeneous, and isotropic.
>
> Time progresses uniformly and (perhaps only locally) unidirectionally.
>
> The scalar relation between space and time is reciprocal, and this relation constitutes *motion.*

CHAPTER III

Where We Stand: Mathematically

The history of theoretical physics is a record of the clothing of mathematical formulae, which were right, or very nearly right, with physical interpretations, which were often very badly wrong.

–Sir James Jeans[52]

One of the important functions of history is to enable us to learn from the experiences of the past, so that we do not have to repeat all of the mistakes of our ancestors. The bit of history cited by Jeans in the foregoing quotation is fully capable of performing this historical function, if we heed its message, as it points very clearly and distinctly to an important limitation on the power of mathematics in the realm of physical science; viz., *mathematical agreement is no guarantee of conceptual validity.*

What this means is that if we devise a theoretical explanation for a certain physical phenomenon, and then formulate a mathematical expression to represent the relations pictured by the theory, or do the same thing in reverse manner, first formulating the mathematical expression empirically and then finding an explanation that fits it, the mere fact that this mathematical expression yields results that agree with the corresponding experimental values does not assure us that the theoretical explanation is correct, even if the agreement is complete and exact. This may seem to be harsh doctrine. Perhaps it is. Certainly it makes the construction of a valid theory a much more difficult task than it would be if mathematical accuracy were sufficient, But nature does not go out of her way to make things easy for the theorist.

Actually, we do not even need the historical record to point the way to this conclusion. Elementary mathematical considerations would tell us the same thing. It is obvious that most mathematical expressions can be subjected to different operations that accomplish results, which are mathematically equivalent. For example, if we start with the equation

x= y/z, we may (1) multiply z by a, (2) divide y by a, or (3) multiply y by n and z by m, maintaining the relationship m/n = a, and in all three cases the effect on the quantity x is exactly the same. The term x becomes x/a. In this example it is obvious that if we merely know that some kind of a change has occurred in the right hand side of the equation, and that this has caused x to become x/a, we cannot say which of the three possibilities that have been enumerated was the one that actually occurred. In fact, the range of possibilities is infinite, since there are an infinite number of combinations of m and n which have the quotient a. If anyone had the hardihood to contend that a decrease from x to x/a is positive proof that z has increased to az, we would simply laugh at him. Such a thing could be true, of course, but it is only one possibility out of many, and claiming that the observed decrease in x is proof of a corresponding increase in z is simply ridiculous.

Yet this is just exactly what the scientific community has permitted Einstein to get away with. If, instead of x = y/z, we write a = F/m, we have one of the alternate expressions of Newton's Second Law of Motion. Experiments on high speed electrons by Kaufmann, Bucherer, and others showed that at these high speeds the observed values of the acceleration a fell below the level computed from the measured values of F and m, following a pattern which indicated that it would reach zero at the velocity of light. Einstein then decided that this was due to an increase in the mass at these high velocities. At this point he should have been told by his scientific colleagues that this variable mass hypothesis was only one of a number of mathematically equivalent possible explanations of the observed phenomenon, and that neither the hypothesis of mass increase nor any of the others could be accepted on more than a very tentative basis pending the accumulation of further evidence. But this is not the way that modern science operates. Einstein's assumption was enthusiastically accepted without further ado, and since that time the original experiments that his explanation was designed to fit, together with subsequent results of the same nature in the particle accelerators, have been regarded as proof of the validity of the hypothesis: a flagrant example of circular reasoning.

The fact is that both Einstein's choice of one particular explanation from among the several available, and the acquiescence of the scientific community in his choice, were based on preferences of a wholly unscientific nature. Since the particles whose acceleration was being

measured in the experiments were given their velocity by electrical means, it was assumed that either mass or electric charge must vary, and variability of mass seemed intuitively more likely than variability of charge. This is, of course, sufficient justification for a tentative hypothesis of mass variation, but it provides no semblance of justification for talk of "proof." Furthermore, in their haste to line up behind Einstein, the physicists have overlooked the fact that the electric charge does not enter the equation of motion directly, and hence even if mass is constant, this does not necessarily mean that charge must be variable; all that is required is that the force exerted by that charge varies with the velocity. The findings of the present investigation are that the charge does remain constant, but that there is no such thing as a constant force. What is now presumed to be a constant force is, in reality, a phenomenon whose magnitude decreases with the velocity of the object to which it is applied, following the inverse of the mathematical relation which is now customarily applied to the mass.

This explanation advanced by the Reciprocal System produces exactly the same mathematical results in application to the behavior of high speed particles as Einstein's theory of an increase in mass. It would therefore be equally entitled to claim that the results of experience "prove" its validity. But, of course, they do no such thing, either for the Reciprocal System or for Einstein. Mathematical agreement proves nothing but mathematical validity. It does not prove conceptual validity; it merely establishes the fact that this particular conceptual explanation could be correct, and it leaves open the possibility that the correct explanation is contained in some other hypothesis that is mathematically equivalent to the one in question. There may well be many such.

Sherwin, for instance, tells us that while there are practical advantages in treating this phenomenon as an increase in mass,

> there is an alternative and more exact way of thinking about the inertial properties of a moving particle… The increased mass is a sort of artifact, which results from the "distorted" measurements of space and time that are the heart of the theory of relativity…Rather than think of the inertial mass as increasing because of its velocity, we could instead think of the particle as possessing a constant rest mass but note that, because of unavoidable effects on the measurement of space and time, the observed deflection of the particle produced by a given impact decreases as its velocity increases.[53]

As Sherwin says, there is no doubt about the experimental fact: "Moving particles are harder to accelerate than the same particles when nearly at rest." But in spite of the confident and categorical assertions that emanate so freely from modern physicists, this experimental fact does *not* prove that mass increases with velocity. There are at least four explanations that have already been suggested: (1) Einstein's hypothesis of an increase in mass, (2) the unwelcome, but nevertheless equally plausible hypothesis of a decrease in the charge (where the applied force is electrical, as it has been in the experiments), (3) the possibility that the observed effect is a result of factors affecting the measurement, as suggested in the preceding paragraph, and (4) the conclusion of the Reciprocal System that the effect of a presumably constant force–electrical, magnetic, or gravitational—actually decreases with the velocity of the object to which it is applied. The mathematical "proof" which is supposed to establish the validity of Einstein's hypothesis applies with equal force to any one of the other three explanations, and it may well be that there are still others as yet unknown which are equally valid mathematically.

This brings us to the issue as to what further steps are necessary in order to establish conceptual validity after mathematical agreement has been obtained. How can we arrive at a definite conclusion as to which of the four hypotheses as to the reason for the decrease in acceleration at high velocities (if any of them) is valid? Here again we can find an answer in a closer analysis of the mathematical situation. Returning to the behavior of high velocity particles, we note that in application to this problem the equation a = F/m contains two unknowns. The acceleration is measured, but the magnitudes of F and m are known only at rest; neither can be measured at high velocity. Mathematical theory tells us that we cannot solve a single equation with two unknowns. We can select values for the unknowns which will make the equation mathematically valid, but these will not be the *correct* values, unless by accident. If the equation represents some physical situation or other meaningful relation, correct values do exist, but in order to determine these values we must have *a set of simultaneous equations.*

The same principle applies to such cases as the one now under consideration. We cannot determine the true reason for the decrease in acceleration at high velocities by a study of this phenomenon alone; we must have at least one independent but related phenomenon which

can be utilized together with the behavior of high velocity particles in a manner similar to the solving of a set of simultaneous equations. Usually it will take an even larger set of auxiliary relationships in this kind of a situation than would be expected on the basis of the number of unknowns that appear to be involved, because these physical relations do not have the exact parallelism that characterizes simultaneous mathematical equations, and furthermore, it is not always easy to determine in advance just how many unknowns enter into the situation.

Invoking the aid of auxiliary relations in an attempt to prove the conceptual validity of a hypothesis can work in reverse and furnish a disproof rather than a proof; indeed, this is the usual result, as the great majority of all theories that are proposed are conceptually wrong. The few that survive represent only a very small fraction of the number originally submitted for consideration. But here again the current tendency is to relax the standards for the benefit of the popular theories of the moment, and to ignore or "explain away" contradictions and discrepancies, particularly if they appear in subordinate or collateral applications of the theory in question.

The current literature of science makes no reference, for instance, to the very obvious fact that Einstein's postulate of an increase in mass at high velocities, the one we have just been discussing, is wholly inconsistent with his explanation of the conversion of mass to energy. Mass cannot be an *accompaniment* of kinetic energy, an entity that increases as the kinetic energy increases, as required by the aspect of Einstein's theories that explains the behavior of particles in the accelerators, and also an entity that can be *converted to* kinetic energy, one that decreases as the kinetic energy increases, as required by the aspect of Einstein's theories that explains the atomic bomb. Both of these aspects of the theories are *mathematically* correct, so far as we are able to determine at present, but they are mutually contradictory from the conceptual standpoint, and therefore at least one of them is *conceptually* wrong. The overwhelming mass of evidence *in favor* of the hypothesis that mass and energy are interconvertible is thus equally overwhelming evidence against the hypothesis that mass increases with velocity.

Since the objective of this chapter is to survey the mathematical knowledge of space and time that is available to supplement the conceptual knowledge described in Chapter II, this discussion of the hypothesis of variable mass may seem somewhat off the main subject,

but a clear understanding of the difference between mathematical knowledge and conceptual knowledge is necessary before we can proceed with our survey, and this variable mass hypothesis provides a particularly good example of the nature of the difference and of the way in which modern science is confusing the two categories. The essential point here is that no matter how definitely the validity of a mathematical relation may be established, this does not in any way confirm the validity of a particular *interpretation* of that relation.

The modern development which is of most particular concern to us in this chapter, because it relates to the inherent nature of space and time, is the Special Theory of Relativity, and the principal relevance of the foregoing discussion of the variable mass hypothesis lies in the fact that this hypothesis, which is itself wholly unsubstantiated and actually in conflict with observed facts, is commonly regarded as one of the main supports of the Special Theory. Furthermore, the logical status of the Special Theory is similar to that of the variable mass hypothesis, in that it is also a well-established mathematical relation, upon which has been placed a conceptual interpretation that is totally unverified and, in reality, has no claim to special merit other than that it is the current favorite among the many possible explanations of the mathematical results.

The existence of alternative explanations is well known and incontestable. Hesse, for instance, tells us that "there are some other logical questions raised by the theory of relativity . . . because there are a number of alternative theories which all appear observationally equivalent."[54] Hutten is equally explicit: "This (the Special Theory) is a prime example of modern scientific method, and it illustrates that facts alone do not make a theory, as is often believed; but that an experiment may be interpreted in many different ways."55 What the physicists have actually done is to examine the alternative explanations, to the extent that they were able to visualize them, and to arrive at the conclusion that the Special Theory is the best of these alternatives. "The principle of relativity was not accepted without a thorough-going analysis of all conceivable alternatives,"56 reports Sherwin.

Unfortunately, the Special Theory is not being presented to us today in its true aspect as the current choice among a number of possible explanations of the mathematical results; it is being presented as the *correct* explanation. "The conceptions of space and time as given by

relativity theory are, even today, accepted as final,"[57] we are told, in spite of the general recognition of the fact that there are other alternatives that are equally well substantiated observationally. Furthermore, the prevailing opinion, as expressed by Sherwin, that "all conceivable alternatives" have been examined is clearly in error. No one is ever in a position to say that there are no other conceivable alternatives. The most that he can legitimately assert is that no other alternatives have yet been thought of, which puts the situation in an entirely different light, as it eliminates any possible justification for the assumption that "the best we have" is equivalent to "correct."

In this present work a new alternative to the Special Theory has been produced. This immediately and automatically destroys the contention that no more alternatives exist, and it cuts the ground out from under the argument that has been the principal support of the Relativity Theory, the argument expressed by Sherwin that it is the best of "all conceivable alternatives." With the knowledge, then, that the Special Theory is only one of many, perhaps very many, possible explanations of the mathematical facts in this case, and that it must justify itself by comparison with observation and experiment in the same manner as any other physical hypothesis, let us briefly review the situation as it now stands.

Whether space and time are absolute or relational—that is, whether they are prior to or determined by events—has been a subject of debate ever since the earliest days of thinking about scientific subjects, but until the closing years of the nineteenth century it was taken for granted that the magnitudes of these entities and of their quotient, velocity, were absolute in the sense that accurate measurements would yield identical values irrespective of the conditions under which the measurements were made. Such a conclusion does not preclude the measurement of relative velocities, but it means that the magnitudes of these relative velocities are themselves absolute, and as stated in the textbooks, "The velocity of body A relative to body C is the vector sum of the velocity of body A relative to body B and the velocity of body B relative to body C."

In 1887 the Michelson-Morley experiment dropped a bombshell into physical theory by demonstrating that the foregoing rule as to the composition of relative velocities does not apply to the velocity of light, and that the measured value of this velocity is constant irrespective of the reference system. By this time, nearly a hundred years later, the sensational impact of the findings of this experiment is beginning to

grow somewhat dim, and there is an increasing tendency to minimize its importance in the development of present-day physical theory, even to the extent, in some cases, of contending that Einstein was not appreciably influenced by the experiment in formulating his theories. But Einstein himself says that the results of the experiment created "one of the most dramatic situations in the history of science."[58] These results were not only totally unexpected, but they caught the scientific world completely unprepared to offer any plausible explanation.

An explanation of sorts was finally devised by Fitzgerald, who postulated that the length of an object in motion contracts in the direction of motion just enough to account for the observed discrepancy. Some theoretical backing for this postulate was subsequently supplied by Lorentz, who attributed the contraction to the effect of motion on the cohesive forces between the molecules, but there was a very definite *ad hoc* flavor about the whole situation, which left scientists very uneasy.

At this point Einstein came on the scene with what is now known as the Special Theory of Relativity. Instead of attributing the contraction to physical changes in the moving objects, he took the drastic step of abandoning the concept of absolute magnitudes of space and time, and postulating that the observed deviations from Newton's velocity relations are due to variability in these space and time magnitudes. According to this viewpoint, intervals of space and time are not fixed but vary with the relative velocity of the objects concerned.

Mathematically, both the Fitzgerald-Lorentz contraction hypothesis and the Special Theory of Relativity are correct. Both are specifically devised in such a manner that their formulation leads to a set of mathematical expressions—the Lorentz transformations—which were obtained empirically and are, for that reason, necessarily in agreement with the facts of observation. The first question involved in the present examination of the Special Theory: Is the theory mathematically correct? can thus be answered in the affirmative. It is mathematically correct because it was specifically designed to fit the results of the experiments.

However, this does not automatically give us the answer to the next question: Is the theory conceptually correct? If it could be established that this theory is the only possible explanation of the mathematical relations, then the theory would necessarily be conceptually correct as well but, as already pointed out, this is, from a practical standpoint, impossible. There is, to be sure, a tendency on the part of the theorists

to conclude that when a problem has been under intensive study by the best minds in the scientific profession for a long period of time and no more alternatives have been discovered, this shows that there are no more alternatives, but this assumes an omniscience on the part of the investigators which the record certainly does not justify.

As brought out earlier in the discussion, such a conceptual situation involving more than one unknown can be resolved only in the same way that a mathematical problem with n unknowns can be solved; that is, by the equivalent of the mathematical device of a set of simultaneous equations. In other words, we cannot establish the conceptual validity of a theory by showing that it explains the phenomenon that it was designed to fit, even if the agreement is complete and exact. In order to prove conceptual validity we must have at least two, preferably several, independent lines of evidence converging to the same theoretical conclusions. This requirement obviously cannot be met by the Special Theory. Even the study of nonuniform motion, which is the phenomenon most nearly related to the uniform motion treated by the Special Theory, has led to conclusions, which are different from, and in some respects inconsistent with, the assertions of the Special Theory. As Bergmann says, the General Theory "discards, in a sense, the conceptual framework of its predecessor."[59]

The independent line or lines of evidence needed to verify the conclusions of the Special Theory would normally come from an application of principles previously established in related physical fields, but it should be realized that up to the time of this present investigation no one has ever applied principles developed elsewhere in physical science, in their original forms and without ad hoc modification, to the solution of this particular problem. On the contrary, the solutions thus far proposed have done just the opposite; they have repudiated principles developed in other areas and previously regarded as firmly established. The ad hoc character of the Fitzgerald contraction hypothesis (which is in disfavor with the scientific community and therefore fair game for criticism) is freely condemned. Čapek reports, "Today this explanation is usually presented as a perfect specimen of an *ad hoc* hypothesis, artificially postulated in order to save the appearances."[60] But Einstein's solution is equally *ad hoc* and open to exactly the same criticism. It, too, is a hypothesis artificially postulated to meet the requirements of this particular situation, and while it is

mathematically correct, as it must be, since it was deliberately designed to fit the mathematical results already available, this does not in any way assure us that the theory is conceptually correct.

It is therefore clear that the conceptual validity of the Special Theory has not been established, but for present purposes we will want to go one step farther and ask: Are there any reasons for believing that its validity will never be established; that is, are there any definite items of evidence to show that it is incorrect? And if we examine the situation carefully and critically, without the partisan bias in favor of the theory that colors the viewpoint of the modern physicist, we must necessarily answer: Yes, there is such evidence.

Before a theory can even undertake to pass the crucial test of comparison with experience, it must be self-consistent. It must agree with itself before there is any object in trying to determine whether it agrees with observation. But the Special Theory is not self-consistent. One serious internal contradiction is revealed by the clock paradox. In the statement of this paradox we assume that a clock B is accelerated relative to another identical clock A and that subsequently, after a period of time at a constant relative velocity, the acceleration is reversed and the clocks return to their original locations. According to the principles of Special Relativity clock B. the moving clock, has been running more slowly than clock A, the stationary clock, and hence the time interval registered by B is less than that registered by A. But the Special Theory also tells us that we cannot distinguish between motion of clock B relative to clock A and motion of clock A relative to clock B. Thus it is equally correct to say that A is the moving clock and B is the stationary clock, in which case the time interval registered by clock A is less than that registered by clock B. Each clock therefore registers both more and less than the other.

Here we have a situation in which a straightforward application of the Special Theory leads to a conclusion that is manifestly absurd. As was emphasized in *Beyond Newton,* this paradox, which stands squarely in the way of any claim that the Relativity Theory is physically valid, has never been resolved except by means which contradict the basic assumptions of the Relativity Theory itself. Richard Schlegel brings this fact out very clearly in a discussion of the paradox in his book *Time and the Physical World.* "Acceptance of a preferred coordinate system" is necessary in order to resolve the contradiction, he points

out, but "such an assumption brings a profound modification to special relativity theory; for the assumption contradicts the principle that between any two relatively moving systems the effects of motion are the same, from either system to the other."[61] Whitrow summarizes the situation in this way: "The crucial argument of those who support Einstein (in the clock paradox controversy) automatically undermines Einstein's own position."[62] The theory based primarily on the postulate that *all* motion is relative contains an internal contradiction which cannot be removed except by some argument based on the assumption that *some* motion is *not* relative.

All of the efforts that have been made by the professional relativists to resolve this paradox depend, directly or indirectly, on abandoning the general applicability of the relativity principle and identifying the acceleration of clock B as something *more* than an acceleration relative to clock A. Moller, for example, tells us that the acceleration of clock B is "relative to the fixed stars,"[63] and those authors such as Tolman, who speaks of the "lack of symmetry between the treatment given to the clock A which was at no time subjected to any force, and that given to clock B which was subjected to … forces … when the relative motion of the clocks was changed,"[64] clothing are simply saying the same thing in a more roundabout way. But if motion is *purely relative* as the Special Theory contends, then a force applied to clock B *cannot* produce anything more than a relative motion—it cannot produce a motion that does not exist—and the effect on clock A must therefore be the same as that on clock B. Introduction of a preferred coordinate system such as that defined by the average positions of the fixed stars gets around this difficulty, but only at the cost of destroying the foundations of the theory, since the Special Theory is built on the postulate that no such preferred coordinate system exists.

This one inconsistency is sufficient in itself to show that the Special Theory is not conceptually correct, in spite of the irreproachable character of its mathematical credentials. It may be a useful theory; it may be a "good" theory; it may, indeed, be the best theory available at the moment (aside from the development in the subsequent pages of this volume); but this evidence shows that it is not the *correct* theory. However, we do not have to rely on this one inconsistency alone; there are other contradictions. One that is closely allied with the clock paradox is the existence of absolute acceleration.

It is true, as the relativists contend, that we cannot determine, without recourse to some external criterion, whether a system is at rest or in uniform translational motion, and this is the principal piece of experimental evidence advanced in support of the relativity postulate. But this evidence only shows that if we deliberately restrict ourselves to the information that we can gain from observation of uniform translational motion within the moving system itself, there is nothing that contradicts the relativity postulate. There is no sound reason, however, why we should bar the use of external criteria as an aid in determining the true facts, and these criteria tell us definitely that absolute motion—that is, motion with reference to the general framework of the universe—does exist. Furthermore, just as soon as we go beyond uniform translational motion we can determine, without reference to external criteria, whether or not the system is undergoing absolute acceleration. Since absolute acceleration is a change in the magnitude of absolute motion, this necessarily involves the existence of absolute motion.

The passengers in a space vehicle, for instance, will have no physical evidence of translational motion within the vehicle after they attain a uniform velocity, but they will be acutely conscious of acceleration during the period just after the rocket is fired, and they will be very aware of the situation if, for any reason, the vehicle begins to rotate. The relativists have never been able to incorporate such accelerations into their system other than by calling them "accelerations relative to the fixed stars" which is merely a euphemism for absolute acceleration.

One of the factors that have helped to create the existing confusion with respect to the logical status of the Special Theory is the introduction of the concept of the ether. As originally conceived, this ether was supposed to be something filling all space and stationary in that space. If there were any such entity, motion with respect to the ether would measure motion with respect to absolute space, and such experiments as that of Michelson and Morley were directed toward a measurement of this kind. Since all such experiments have failed to yield a positive result, it has by this time been demonstrated, to a reasonable degree of certainty, that motion of the earth with respect to absolute space cannot be detected by measurement of motion with respect to a hypothetical ether. At this point the logical conclusion would have been that resort to other means to accomplish this purpose would be necessary, but in

the meantime Einstein had come forward with his theory based on the assumption that absolute space and absolute motion do not exist. The scientific world was desperately anxious to have some kind of a plausible explanation of the results of the Michelson-Morley experiment, hence in order to accommodate the new theory and prevent its immediate destruction, the physicists took the position that they would refuse to concede the existence of absolute space and time unless this existence could be demonstrated by some means within the moving system itself. In effect, this ruled out any possible universal frame of reference other than an ether. As Arthur Beiser states the "official" position: "The absence of an ether, then, implies that there is no universal frame of reference, so that all motion exists solely relative to the person or instrument observing it."[65]

In this way the use of external criteria for the purpose of determining absolute motion was arbitrarily ruled illegal. This is a most astounding innovation in scientific procedure. We are quite familiar with such situations in jurisprudence. Many a lawbreaker has gone free because the rules of evidence would not permit the introduction of the testimony which would have convicted him. But bringing this kind of thing into science is not only unprecedented, but completely out of order. Nature recognizes no "scientific rules of evidence,, and there is no sound reason why science should tie its own hands. Since we cannot observe locations in space directly, we must identify them by means of something observable that is present therein, but there is no necessity that this be an ether, or anything resembling an ether. On the contrary, we are on much more solid ground if we utilize objects that we know actually exist, rather than something purely hypothetical. The obvious choice for a reference system is the spatial framework defined by means of the fixed stars.

Whether or not we regard this reference system as defining an "absolute space" is immaterial. Some of the professional relativists concede that it does. Moller, for instance, admits that "the fixed stars as a whole may be regarded as approximately at rest relative to the 'absolute space.'…"[66] Eddington has made a similar concession. But in any event, these stars provide us with a universally applicable frame of reference, the kind of a "preferred coordinate system", that Relativity claims does not exist, and whether or not we call it "absolute space" is merely a question of semantics. Motion relative to this universal

frame of reference is exactly the same thing, from the scientific and practical standpoints, if not philosophically, as the "absolute motion" that the world of science knew before Relativity came on the scene. The frequency with which the relativists themselves call upon "motion relative to the fixed stars" to get out of tight corners is clear evidence of how necessary an absolute framework actually is, even to those whose basic theories rest upon a denial that any such thing exists. It is also highly significant that the astronomers, the scientific group whose work is the most directly affected by the principles of Relativity, carry out their calculations in callous disregard for those principles, just as if they had never heard of Einstein, even though, as loyal members of the scientific community, they may pay lip service to this phase of current scientific dogma. McVittie tells us explicitly:

> In discussing stellar proper motion and radial velocities, astronomers tacitly assume that these represent the rates of change of local distances with respect to the absolute time of classical Newtonian mechanics. Moreover local distance is identified with the absolute distance of classical theory.[67]

In addition to the direct evidence against the conceptual validity of the Special Theory which is supplied by the clock paradox and the existence of absolute acceleration, the inability of the adherents of this theory to extend its field of applicability or to establish firm connections with other physical theories, in spite of the immense amount of effort devoted to the task is, in a sense, additional direct evidence against it, because non-uniform motion is so closely related to uniform motion that a conceptually valid theory applicable to the more limited field should be capable of extension to the general case without any serious difficulty. We must therefore conclude that the conceptual validity of the Special Theory is not only *unproved* but definitely *disproved*. The situation with reference to the General Theory will not be considered in this volume, as this phase of the Relativity ideas is outside the scope of the present discussion. It was, however, examined in detail in *Beyond Newton*.

The question now arises, If the foregoing conclusions are correct, and this can hardly be denied if the issues are squarely faced, why are present-day scientists so thoroughly convinced of the validity of the Special Theory? Why do front-rank scientists make categorical assertions such as the following from Heisenberg:

> The theory… has meanwhile become an axiomatic foundation of all modern physics, confirmed by a large number of experiments. It has become a permanent property of exact science just, as has classical mechanics or the theory of heat.[68]

We can throw some light on these questions by considering the following two statements:

A. As a mathematical problem there is virtually only one possible solution (the Lorentz transformation) if the velocity of light is to be the same for all. (Sir George Thomson)[69]

B. There was and there is now no understanding of it (the Michelson-Morley experiment) except through giving up the idea of absolute time and of absolute length and making the two interdependent concepts. (R. A. Millikan)[70]

The logical structure of both of these statements (including the implied assertions) is the same and can be expressed as follows:

1. A solution for the problem under consideration has been obtained.
2. Long and intensive study has failed to produce any alternative solution.
3. Hence the original solution must be correct.

In the case of statement A, this logic is irrefutable. It would, in fact, be valid even without any search for alternatives. Since the original solution yields the correct answers, any other valid solution would necessarily have to be mathematically equivalent to the first, and from a mathematical standpoint equivalent statements are simply different ways of expressing the same thing. The statements $x = ab$ and $x/a = b$, for example, are not two different mathematical relations; they are simply two different ways of stating the same relation. Hence as soon as we obtain a mathematically correct answer to a problem, we have *the* mathematically correct answer.

Statement B is an application of the same logic to a conceptual rather than a *mathematical* solution, but here the logic is completely invalid, as in this case alternative solutions are different solutions, not merely different ways of expressing the same solution. "A physical theory consists of a formal calculus and an interpretation," explains Hutten, "but the relation between calculus and interpretation is in fact not unique. A single calculus may be interpreted in terms of various concepts."[71] Merely finding an explanation, which fits the observed facts, does not, in this case, guarantee that we have the correct explanation. As brought out previously, we must have additional confirmation from other sources before conceptual validity can be established.

Furthermore, the need for this additional evidence still exists as strongly as ever even if the theory in question is the best explanation that science has thus far been able to devise, as it is, or at least should be, obvious that we can never be sure that we have exhausted the possible alternatives. The theorists do not like to admit this. When they have devoted long years to the study and investigation of a problem and the situation still remains as described by Millikan—that is, only one plausible explanation has been found—there is a strong temptation to assume that no other possible explanation exists, and to regard the existing theory as necessarily correct, even though, as in the case of the Special Theory, there may be specific evidence to the contrary. Otherwise, if they do not make such an assumption, they must admit, tacitly if not explicitly, that their abilities have thus far been unequal to the task of finding the alternatives. Few human beings, in or out of the scientific field, relish making this kind of an admission.

Here, then, is the reason why the serious shortcomings of the Special Theory are currently looked upon so charitably. Nothing better is now available, and the physicists are not willing to concede that they might have overlooked the correct answer. But the facts are clear. No new *conceptual* information has been added to the previously existing body of knowledge concerning space and time by the Michelson-Morley experiment and the theoretical developments aimed at explaining the results of that experiment. The Special Theory of Relativity is nothing more than an erroneous hypothesis: a conspicuous addition to the historical record cited by Jeans; another example of a mathematical formula that is right, or very nearly right, clothed with a physical interpretation that is very badly wrong.

To many of those who, from their earliest contacts with physical science, have been taught that the Special Theory "belongs to the firm foundation of modern physics and cannot be disputed in our present situation," as Heisenberg puts it, this conclusion may seem almost incredible, but the realization that the mathematical validity of the Lorentz transformations is no proof of the validity of Einstein's *interpretation* of these mathematical results has been growing. "It must be admitted, however, that Einstein's original interpretation of the special theory of relativity is hardly ever used by contemporary physicists," says Feyerabend, "For them the theory of relativity consists

of two elements: (1) the Lorentz transformations; and (2) mass-energy equivalence."[72] Bridgman also comments on the tendency "to define the content of the special theory of relativity as coextensive with the content of the Lorentz equations," and he points out that on this basis there is no "theory" of relativity:

Nothing explicit in the (Lorentz) equations themselves determines the nature of the physical application, but this has to be specified in some way apart from the equations. Not until we have specified the details of the physical application do we have the right to speak of the equations as part of a physical "theory."[73]

The emotional reaction of most physicists to any suggestion that Einstein's theory will have to be abandoned is largely due to a mistaken impression that the choice is between Einstein and pre-Einstein; that the proponent of change is advocating a retreat to positions that are now known to be untenable. But as long as we concede the validity of the Lorentz equations a return to pure Newtonian theory is impossible. The findings presented in this work do not suggest a retreat from Einstein to pre-Einstein; they suggest an advance from Einstein to post-Einstein. The Special Theory of Relativity is mathematically correct but conceptually wrong. What is needed is not to abandon the correct mathematical structure, but to discard Einstein's erroneous interpretation of the mathematical results, an action that, as Feyerabend and Bridgman report in the foregoing statements, is already under way, and then to ascertain what new concepts are necessary in order to produce a theory that is both mathematically and conceptually correct.

The correct theory of space and time must therefore be based not only on the conceptual information summarized at the end of Chapter II, but also on the additional mathematical information about these two entities which has been obtained from the Michelson Morley experiment and the subsequent studies of the results of that experiment. This information may be expressed as follows:

> The velocity of light is independent of the reference system.
>
> Other velocities measured in the normal manner in one reference system can be expressed in terms of another reference system moving translationally at a constant speed relative to the first system by means of the mathematical relations known as the Lorentz transformations.

CHAPTER IV

Laying the Foundation

One of the most interesting questions that has arisen out of the activities of modern science is that of the ultimate future of the human race. There is no doubt but that *homo sapiens* is a very adaptable species—he manages to thrive anywhere within a surprisingly wide range of environments, climatic and otherwise—but it is still an open question whether he has attained a degree of adaptability comparable to that of the cockroach, for example, which will enable him to survive for millions of years, or whether *sapiens* will sooner or later give way to some new and more advanced species, just as he superseded *homo erectus* and *erectus* replaced his pre-human ancestors. This intriguing question is not likely to receive an authoritative answer anytime in the near future, but for the purposes of the present chapter let us indulge in a little flight of fancy and assume that these evolutionary processes have actually taken place and that *homo sapiens* has been supplanted by a super-race. Then let us further assume that we who are now concerned with the subject matter of this volume as author and readers are a group of individuals of that super-race—*homo super-sapiens,* let us say—to whom has been assigned the task of ascertaining the nature of the basic structure of the physical universe.

Before we can don the robes of the super-scientist and proceed with our project it will first be necessary to give some consideration to the question as to just what advantage super-sapiens has over his predecessor. Those who speculate about the possible emergence of a super-race usually envision a great increase in intelligence: a rise in the average I.Q. to perhaps 300 or 400. If we adopt this viewpoint we will have to abandon our undertaking before we get started, as reproducing the mental processes of a vastly more intelligent race is clearly an impossible task. But an increase in the intelligence level is not the only way in which a super-race might develop.

One of our prominent science fiction writers has just recently published a story in which a superior race develops simply by suppressing the emotional reactions that govern so much of the activity of *homo sapiens,* and basing all decisions and actions on logical analysis and reasoning. This we should be able to duplicate, at least on a particular assignment and for a short period of time, if we put forth the necessary effort.

Of course, science already accepts such a code of procedure in principle, but there is a wide gap between that which scientists subscribe to as a matter of principle and that which they do in actual practice. In principle valid criticism of accepted ideas should be hospitably received as a worth-while contribution to scientific knowledge; in practice such criticism is strongly resented by the "experts" in the particular field involved, and in line with the old adage that "it is the truth that hurts," the more pertinent the criticism the stronger the resentment. In principle a new idea of merit should be welcomed with open arms; in practice even a relatively modest proposal for modification of existing viewpoints is looked upon with distaste and suspicion, while a major new development has to fight every inch of the way. The most important and most valuable discoveries are not exempt from this treatment; on the contrary they often meet the most hostile reception. Some, like Mendel's basic findings in the field of genetics, or Waterston's pioneering formulation of the kinetic theory, never did succeed in penetrating the wall of prejudice and disinterest, and these important discoveries simply remained dormant until they were rediscovered by someone else many years later. Other important scientific advances prevailed only by overcoming strong opposition, based more on emotional than on logical grounds. For example, Planck's theory of the quantum, now recognized as one of the most important of modern scientific developments, was accepted only after a long and difficult struggle, during which, Planck complains bitterly, his "sound arguments fell on deaf ears."[74]

In order to assume our roles as members of the *super-sapiens* race for purposes of the present inquiry it will be necessary not only to lay aside the emotional preferences and prejudices which lead *homo sapiens* to violate his own code of scientific procedure, but also to overcome the characteristically human distaste for leaving the comfortable groove of established thought. These are difficult, but not impossible, requirements. Let us therefore adjust our thinking to the *super-sapiens* pattern and proceed with a cold-blooded, logical and systematic study of the problem at hand.

With the benefit of the logical approach to all questions that characterizes our super-race, it is obvious, to begin with, that the proper way of analyzing a complex subject of this kind is to explore its simpler and more basic aspects first, and then gradually work toward the more complicated details. As our first step, then, we will want to study the nature and properties of some of the fundamental entities of the universe. It is not absolutely essential that we start with the most fundamental, but there are some definite advantages in so doing, and the first item in our program should therefore be to identify the most fundamental entities that we can find in the physical universe. Although the various physical entities do not carry labels which brand them as fundamental or not fundamental, there is little doubt but that the leading candidates for the distinction of being most fundamental are space and time.

There are other points of view, of course. Some would give matter the preference over space and time or, at least, assign it a coordinate position. Supporters of the relational hypothesis of space and time are also likely to raise the contention that "events" are logically prior to space and time and hence the latter cannot be fundamental. But it should be remembered that this conclusion is purely hypothetical and even though it happens to be the hypothesis that has been most favored by *homo sapiens,* the opposing concept of space and time existing prior to events cannot be ruled out. Furthermore, it is clear that both matter and events are very complex entities, whereas space and time appear to be simpler. The choice of space and time as the initial subjects for investigation therefore seems well founded, particularly when we bear in mind that it is not essential that we start with the most basic entities. If we have made the wrong choice here we do not put any insurmountable obstacle in the way of success in our undertaking; we merely make our task somewhat more difficult.

Thus our first problem is to determine the general nature of space and time and the relationship between them. Since only a relatively small portion of the universe is accessible to direct and accurate observation, we cannot make such determinations directly, and what we have to do is to assume some properties and relations, develop the consequences of these assumptions, select those of the consequences which fall within the accessible area, and then compare these theoretical consequences with the observed facts. If they disagree, then one or more of our

assumptions is incorrect, and we must go back and start all over again with new assumptions. If there is full agreement, then the validity of the assumptions is substantiated to a degree, which depends on the number and variety of the correlations that were made. The immediate question, therefore, is, What assumptions shall we make?

Here, again, the clear and unprejudiced vision of a super-race makes the proper course evident; showing us that such a question can best be approached by first examining the general situation in which we are considering the relation of any quantity x to any other quantity y. In this general situation there will be a region accessible to direct observation and another region which is not accessible. The relation in the accessible region can, of course, be determined by direct means, and what we need to ascertain in order to complete our knowledge is the relation in the inaccessible region. Since this relation is, by definition, unknown, it could be almost anything, and the range of possible assumptions is almost unlimited. But when we consider this general situation, without the distracting influences, which always accompany consideration of any specific physical situation, it is apparent that there is one possible assumption, which is far superior to all others. This greatly superior assumption is the assumption that the relation, which we find in the region accessible to observation also, holds well in the inaccessible region.

As has been pointed out, our original hypothesis, whatever it may be, will ultimately have to be tested by developing its consequences in all of the physical fields to which it is applicable and determining whether or not these consequences agree with the facts of observation and measurement. But the extrapolation assumption — the assumption that the situation which we observe in our local sector of the universe prevails throughout the universe as a whole — is initially by far the best hypothesis that we can make: one that not only has a far greater *a priori* probability of being correct than any other possible assumption, but a much greater probability than all other possible assumptions combined. For example, the fact that space is three-dimensional where we are in direct contact with it does not guarantee that it is three-dimensional everywhere and that this is a general property of space, but it means that there is an extremely strong probability that this is true and that the existence of an n dimensional space in which n has a value other than three is very unlikely.

If we were looking at this issue through the eyes of *homo sapiens* there would no doubt be some tendency to question whether the *a priori* probability of the validity of an extrapolation of a physical relationship is as great as indicated in the preceding paragraph, because *sapiens* is very much over impressed by certain highly publicized 20th Century developments in physics which are currently interpreted as proof that some of the basic relations which govern the world of everyday experience—Newton's Laws of Motion, for example—cannot be extrapolated to the realms of the very small and the very large. But a race which looks at everything from a logical and factual standpoint, without being influenced by emotional arguments or propaganda in favor of the popular ideas of the moment, will realize that even if this were true, the number of items involved is extremely small compared to the enormous number of instances in which science has made extrapolations into regions beyond the then current range of observation, and subsequently, through the invention of improved methods or instruments, has verified the accuracy of the extrapolations.

Furthermore, the clear-thinking super-scientist will realize that the so-called "failures" of the extrapolated relations in the cases mentioned are only hypothetical. On first consideration *homo sapiens* would probably regard this statement as absurd. The Laws of Motion are accurate and dependable in application to macroscopic events, but they admittedly do not give the correct results when they are applied to events at the atomic level. It seems, therefore, that extrapolation of these laws to the microscopic realm has been a failure. But those who look at the situation in this light are overlooking the fact that this is not simply an extrapolation; it is an extrapolation plus an assumption. Newton's Laws of Motion are applicable at the level of our ordinary experience to the kind of motion which is there encountered, and a pure extrapolation would lead to the conclusion that the Laws are applicable to this kind of motion wherever it exists. But in order to apply these laws to events at the atomic level it is necessary not only to extrapolate the application of the laws but also to *assume* that the atomic motion is the same kind of motion as that encountered in the macroscopic world. If this assumption is erroneous (and the subsequent development in this volume will show that it is, in fact, erroneous) then the so-called "extrapolation" is not an extrapolation at all.

Careful examination will disclose that most of the "failures" of extrapolated relations are of this nature. The so-called extrapolations are, in reality, extrapolations plus one or more assumptions, and the fault lies in the erroneous nature of the assumptions, not in the inapplicability of the relations that are being extrapolated. Such "failures" are, of course, completely irrelevant to the question as to the reliability of the extrapolation process, and when we exclude them from consideration, the number of cases where extrapolated physical relations have been found inapplicable is insignificant compared with the vast number of successful applications. Since it is the mathematical expression of experience that determines the probability, the previous statement as to the strong a priori probability of the validity of the extrapolated relations is amply supported.

The inherent superiority of the extrapolation process is all the more important because it is not usually possible to test the consequences of a single physical hypothesis in isolation. Most of the phenomena, which we must use for test purposes, are complex events that are not the result of a single property of space or of time but are results of a number of properties of both space and time. Even the most casual consideration of the probability principles is sufficient to emphasize the tremendous advantage to be gained by the extrapolation of the results of observation under such circumstances. Where the probability of any one hypothesis being correct is very low, as is true when pure assumptions are made concerning physical processes or properties, the probability that all of several such hypotheses are correct is almost negligible. Furthermore, the probability that all but one of these hypotheses is correct is likewise extremely small. On the other hand, if each individual hypothesis has a high probability of being correct, as is true when these hypotheses are extrapolations, the probability that more than one of them is incorrect is close to zero. In this case, if the original set of assumptions fails to produce the correct results, the search for the correct answer can be a matter of substituting other assumptions one at a time for each of the original assumptions in turn. A search of this kind is a tremendous undertaking, to be sure, but it has some chance of success, whereas if two or more of the original hypotheses are incorrect, so that the one at a time technique of substitution is precluded, the odds against success are almost prohibitive.

Our consideration of the general situation thus leads directly to the conclusion that the procedure in carrying out the assignment of determining the basic structure of the physical universe should be to ascertain the properties of space and time and the relations between these two entities as they are manifested in the region accessible to direct observation, extrapolate these properties and relations to the universe as a whole, develop the consequences of the hypotheses thus derived, and then determine whether these consequences are in agreement with the observed facts. There is a very strong a priori probability that we will find full agreement, and if so, the set of assumptions derived in this manner is correct; if there is any discrepancy, one of the assumptions, but almost certainly no more than one, is in error. What we will then have to do is to locate the error, make the necessary change in our postulates, and repeat the original procedure.

The positively established conceptual knowledge concerning the properties of space and time in the region accessible to direct observation and the nature of the relation between these two entities in the accessible region were summarized at the end of Chapter II. In accordance with the conclusions stated in the preceding paragraph, we will now proceed to generalize these findings (omitting the one uncertain item) and express them as hypotheses applicable to the entire universe. In this manner we arrive at the following hypotheses:

> Space is three-dimensional, homogeneous and isotropic throughout the universe.
>
> Time progresses uniformly throughout the universe.
>
> Throughout the universe the scalar relation between space and time is reciprocal, and this relation constitutes motion.

One conspicuous feature of these hypotheses is the absence of the usual assumption as to the one-dimensionality of time, an assumption which, in view of the points brought out in Chapter II, can no longer be regarded as having any observational support. At this stage, however, no postulate of multi-dimensionality is being advanced. All that we are doing at the moment is to determine what hypotheses as to the properties and relations of space and time in the universe as a whole can be legitimately derived by extrapolation of our direct observations, and these direct observations tell us nothing at all about the dimensions of time.

Since we are viewing this situation with the clear insight of a superrace, rather than through the veil of prejudices and preconceived ideas that hampers *homo sapiens* in his reasoning, it will be apparent to us that *the logical status of all of the assumptions in the foregoing list is identical.* In each case the situation in the known region is clear and unequivocal; we have eliminated those items that are in any way questionable. Hence the inherently strong probability of validity that attaches to any extrapolation from the known to the unknown applies with equal force to all these assumptions. This does not mean that all must necessarily be true if one is true, but it means that there is no justification for any advance judgment that one is more likely to be correct than another.

This point is particularly important because some of these assumptions are thoroughly familiar to *homo sapiens* and are accepted by him as practically axiomatic, whereas others are not only entirely unfamiliar, but also wholly foreign to established human habits of thought on these matters, and hence subject to the antagonism with which the human race tends to greet heresy in any form. Scientist and layman alike are strongly inclined to classify some ideas as "reasonable" and hence believable, while others are regarded as "unreasonable" and consequently unworthy of serious consideration. But what this really amounts to is prejudging the case on emotional grounds before the evidence is presented. It is quite true that many of the ideas or assumptions that are proposed are self-contradictory or in direct conflict with firmly established facts, and such items certainly cannot be accepted, but neither these nor any other ideas should be condemned on the basis of any advance emotional judgment. If they must be rejected, this should be done only after the evidence is at hand. Where conclusive evidence can easily be obtained, the verdict can be reached quickly, but there is never any justification for reaching positive conclusions without adequate evidence.

When we look at the situation now under consideration from the standpoint of pure logic, without the emotional overtones that are so characteristic of human reaction to innovations, it is evident that, as long as our observations in the accessible regions are definite and positive, we are just as much entitled to extrapolate one as another, and our general knowledge of the extrapolation process justifies the assertion that each and every one of the assumptions derived

by extrapolation is very probably true. Before we can take the next step and assert that they are, in fact, true, it will be necessary to demonstrate their validity in the standard manner by showing that they meet the test of comparison with experience, but it should be recognized at the outset that there is but little chance that they will fail to meet the test.

It is particularly essential to keep this fact in mind when the first deductions as to the direct consequences of these basic assumptions are made, because the conclusions thus derived will seem very strange—perhaps altogether incredible—to those who are imbued with previous ideas and concepts, and even a super-race may find the necessary adjustment of thinking rather difficult. The first conclusion of this kind that we draw from the extrapolated assumptions is that inasmuch as these specify the existence of a general reciprocal relation between space and time, there must be complete scalar symmetry between these two entities. All properties, which are possessed by either space or time individually, are therefore properties of both space and time. *We thus arrive at the conclusion that both space and time are three-dimensional, homogeneous and isotropic, and both progress at a uniform rate.*

Every conclusion that we derive from the original hypotheses offers us an opportunity to test the validity of the entire system of hypotheses plus derivatives. Such a test cannot give us a positive result; that is, even if the conclusion is found to agree with the observed and measured facts in all respects, this does not assure us that the system is valid, since there is still a possibility of conflict with other facts at present unknown, a possibility that can be eliminated only by complying with some much more stringent requirements. But any test can give us a *negative* result. If the conclusion conflicts with *any* positively established fact, this is sufficient for disproof. The conclusion that all properties of either space or time are properties of both space and time would be immediately demolished if any of the properties extrapolated from one to the other turned out to be inconsistent with established facts, and in view of the great differences which appear to exist between space and time as we ordinarily envision them it would seem offhand that discrepancies of this kind should be easy to locate. But we will find on close examination that this is not the case; there is no conflict or inconsistency anywhere.

It is true that the concept of three-dimensional time is in direct conflict with the ideas of *homo sapiens*, but it is only conflicts with facts that are fatal, and human ideas as to the dimensions of time are not factual. As brought out previously, the long-standing concept of time as one-dimensional is based on a misunderstanding of the nature of time dimensions. A dimension of time is not a dimension in space, nor is it anything space-like; it is a property of time itself. The scalar nature of the time term in the equations of motion is not a result of time being one-dimensional; it results from the fact that *time has no direction in space,* regardless of how many dimensions or directions of its own it may have. Thus there is nothing at all in our observations that precludes time from being three-dimensional, as required by the conclusion that time has all of the properties which we observe in space.

To those who are accustomed to thinking along different lines, the idea of a progression of space similar to the observed progression of time may seem even more outrageous than the concept of three-dimensional time, but the fact is that we have actual observational evidence of such a progression. Of course, we cannot see locations in space, but we can see objects which occupy locations in space, and by means of the giant telescopes now in service we can see objects—galaxies—which are so far away that any random motions which they may possess are unobservable, and the effect of gravitation is attenuated to the point where it is no longer a controlling factor. Under these circumstances, if there is a progression of space, as our theoretical development requires, the spatial locations occupied by these distant galaxies should be moving steadily outward away from us, carrying the galaxies with them. *This is just exactly what our observations indicate is actually happening.*

We normally visualize the progression of time as a unidirectional flow rather than an outward movement, but this is pure assumption. As brought out in Chapter II, the presumed one-dimensional flow of time is actually scalar rather than one-dimensional, and when we analyze the motion of the distant galaxies, this also turns out to be scalar. The recession of any galaxy A has a definite direction MA when viewed from M, our own Milky Way galaxy, but the direction of the recession is BA when viewed from galaxy B. CA when viewed from galaxy C, and so on, which means that the motion actually has no specific direction. It is simply a scalar motion, outward from all other galaxies.

The significance of a positive and unequivocal confirmation of this kind can hardly be overestimated, as there is a tremendous difference between the standing of a purely ad hoc hypothesis and that of a hypothesis which is derived from one source and confirmed by independent evidence from another physical source. Such hypotheses as those of a "nuclear force" that holds the hypothetical constituents of the atom together, the "propagation" of gravitation that is presumed to transmit the gravitational effect from one mass to another, or the mysterious unnamed "force" that is supposed to induce atoms to acquire or lose electrons to attain the inert gas configuration, are nothing more than euphemisms for ignorance. What meaningful difference is there between saying that no one knows what holds the constituents of the atom together and saying that they are held together by a "force" dreamed up for this specific purpose and totally unknown in any other connection?

But a hypothesis such as that of the progression of space, which is *derived* by theoretical reasoning based on extrapolation of our observations of space and time in our everyday experience, and is then *corroborated* by an entirely different physical phenomenon altogether remote from our daily experience, the recession of the distant galaxies, is something of a much different character. With the benefit of this information, we are in a position to assert that we have here increased our actual *knowledge* of the physical universe, and to look forward with confidence to additional successful applications of this same hypothesis in other physical areas, which will not only represent further advances in scientific knowledge, but will still further strengthen the already strong position of the hypothesis itself. For instance, in one of the many such applications discussed in the subsequent pages, it will be shown that the photon of light, like the distant galaxy, behaves in exactly the manner required by the hypothesis of space-time progression.

This completes the first phase of our committee assignment. Since the conclusion that both space and time have all of the properties observed in either space or time individually has been derived by means of processes which are entitled to a high degree of confidence, and since there is no factual evidence that is inconsistent with this conclusion, whereas there is strong evidence supporting the validity of the innovations which it introduces into physical relations, we are

justified in considering this conclusion as correct. This extends our knowledge of space and time very substantially, and when all of the knowledge that we now possess is explicitly stated in systematic form we will have arrived at the kind of a basic theory of the structure of the universe that our committee was instructed to produce. Before we can express this theory in a suitable form, however, there are a few additional points to be considered.

One question that we will want to examine is whether space and time are continuous or exist in discrete units. Here we find that throughout the history of science there has been a steady growth in the recognition of discontinuity in the physical world. At the time the atomic structure of matter was first proposed, all other primary physical phenomena were thought to be continuous and infinitely divisible. As knowledge has grown, however, more and more of these have been found to exist only in units. The discrete nature of electric charge and of radiant energy are already well confirmed, and there is increasing evidence for the existence of basic units in other phenomena, such as magnetism, for instance. If we project this trend, we can reasonably arrive at the conclusion that when all of the facts are known, the basic entities, space and time, will also be found to exist only in discrete units.

Further mathematical development will show that the limitation of space and time to discrete units is a necessary consequence of the postulates previously formulated, particularly the reciprocal postulate, but for the present it will be preferable to regard this as an additional assumption justified by projecting existing trends in the increase of physical knowledge, as indicated in the preceding paragraph. We will therefore add such an assumption to our list.

Another issue which requires consideration is whether space and time, as we now see them in the light of our new knowledge, together with the consequences that necessarily ensue because of the existence of these two entities with the properties which we now know that they possess, have a broad enough scope to constitute a complete physical universe, or whether the existence of some additional basic entities, such as matter, for example, must be postulated in order to complete the theoretical picture. Here we have no option but to make a pure assumption. It is clearly undesirable, however, to introduce additional complexity into the theoretical development until the

necessity for so doing actually arises, and we will therefore start with the postulate that space and time are the only constituents of the physical universe. Additional factors can be introduced if and when this becomes necessary, without invalidating any progress that may have been made up to the point that such action is taken.

In formulating a statement of this postulate we encounter a question as to whether we should consider space and time as separate but related entities, or as two different aspects of the same basic entity, and in case we choose the latter alternative, a further question as to whether we should call this entity space-time or motion. These questions have no bearing on the development of thought and we are therefore free to make our choice on the ground of convenience.

From this standpoint it seems advisable to select those terms which will be most understandable in the context of existing thought and which will facilitate explaining the new theoretical structure to individuals who are familiar with previously accepted ideas. We will therefore say that the universe has only one component, and for the present, we will call this component space-time, with the understanding that this term is equivalent to motion, when motion is taken in the most general sense.

Although the progression of space-time is one of the items of knowledge obtained by extrapolation of our observations in the known region of the universe, we do not need to include this progression in the postulates because it is a necessary consequence of the other assumptions derived by the extrapolation process. The same is true of the homogeneity and isotropy of space and time and the uniformity of the progression. In our restatement of the basic postulates we will therefore omit these items. It should be understood, however, that they are essential to the theoretical development, and if any question is raised as to the validity of their derivation from the remaining assumptions, this merely means that they must be restored to the basic postulates. The course of the subsequent development will not be altered by any such question.

In addition to the assumptions that have been made concerning the physical nature of the universe, it will also be necessary to make some assumptions as to its mathematical behavior. Here again we will follow the same procedure, extrapolating the relations which we find existing in the region accessible to direct observation, and assuming

that they apply to the universe as a whole. In this manner we arrive at the assumptions that the universe in general conforms to the relationships of ordinary commutative mathematics, its magnitudes are absolute, and its geometry is Euclidean.

Our committee is now ready to make its first progress report. In this report we will say that we have found it possible to apply a very reliable process—extrapolation of observed relationships—to the problem assigned to us, and that by utilizing this process exclusively, without introducing any unsupported or ad hoc assumptions we have been able to formulate two postulates as to the basic nature of the physical universe which have a very high degree of probability of being correct. A full development of the consequences of these postulates should lead to a complete definition of the structure of the universe. The postulates can be expressed as follows:

> *First Fundamental Postulate:* The physical universe is composed entirely of one component, space-time, existing in three dimensions, in discrete units, and in two reciprocal forms, space and time.
>
> *Second Fundamental Postulate:* The physical universe conforms to the relations of ordinary commutative mathematics, its magnitudes are absolute and its geometry is Euclidean.

At this point we will step out of our *super-sapiens* roles and return to the more prosaic world of human activities. The super-committee still has ahead of it the task of proving the validity of the postulates, and this can be accomplished by applying similar logical and systematic processes, but the objective of this present volume is to clarify the ideas and concepts of the new theoretical structure, not to prove that it is correct. Most of the requirements for proof have been met in previous publications, and whatever gaps still remain, or may seem to exist, will be handled in future extensions of or additions to those works. The nature of the proof that has been and will be offered is, however, germane to the subject of the present volume, and will be discussed in the next chapter.

CHAPTER V

Some General Observations

It is not necessary to be a member of the kind of a super-race envisioned in the preceding chapter in order to arrive at the postulates that were there formulated. But it took the author of this book almost twenty years to reach these conclusions by the slow and painful processes that man normally employs when he attempts to change the direction of his thinking, whereas the preceding discussion shows that they could be reached in less than twenty minutes by following the cold-blooded, logical and systematic course of procedure that we could expect *homo super-sapiens* to utilize.

Because of the inherently strong probability that the results of extrapolation are valid, we know in advance that the two Fundamental Postulates which express the conclusions of the investigation are almost certainly a correct representation of the basic relations of the actual physical universe but, of course, we will want to eliminate the qualification "almost" from the foregoing statement, and the second major objective of the present project has therefore been to prove that these postulates formulated in the first phase of the project are, in fact, correct. As indicated in the introductory chapter, the method that has been utilized to accomplish this proof is that of reducing the probability that the postulates are incorrect to the point where this probability is negligible.

In carrying out this program the necessary consequences of the postulates have been developed in much detail and the validity of the conclusions reached as a result of this development has been established by comparing these theoretical conclusions with the results of observation and measurement. The feature of the theoretical development which makes these comparisons so significant is that even though the conclusions reached by this means are so numerous and so all-embracing that they constitute a complete theoretical universe, yet the entire system has been derived solely from the two Fundamental

Postulates without introducing anything from the observed physical universe or from any other outside source. The mere existence of space and time with the postulated properties gives rise to certain primary consequences. Interaction of these consequences with each other and with the postulates then results in a large number and variety of secondary consequences, which, in turn, involve further consequences, and so on until a whole theoretical universe has been defined.

In view of a rather general reluctance to believe that such a thing is possible, because previous efforts to unify physical theory have been wholly unsuccessful, it seems advisable at this point to emphasize the fact that the statements in the preceding paragraph mean just exactly what they say. The development of the consequences of the Fundamental Postulates leads not only to a definition of the relations between physical entities, all that is normally expected of a theory, but also requires the existence of these entities, and where numerical values are involved, indicates the magnitudes, or at least the possible magnitudes, of such values. Matter, for example, is not brought into the system because we find it in the observed physical universe. An entity with the properties that we observe in matter must exist if the Fundamental Postulates are valid. It must exist in the form of a series of elements, these elements must combine in certain ways and no others, the elements and their compounds must have certain properties such as volume, specific heat, etc., these properties must conform to certain sets of numerical values, and so on. All of these are necessary and unavoidable consequences of the two postulates: purely theoretical conclusions that are, so far as their origin is concerned, completely independent of what we observe in the actual physical universe.

The entire Reciprocal System, consisting of the two Fundamental Postulates together with their necessary consequences, is thus a single integral unit. If the postulates are valid, then each and every one of the necessary consequences is likewise valid. Conversely, if even a single one of the thousands of these necessary consequences conflicts with a fact that has been definitely established, the postulates are thereby invalidated and the entire structure falls. This unitary character of the system is the feature that makes proof by the probability method possible.

An analogy that was discussed in considerable detail in *Beyond Newton* compares the construction of a physical theory to the preparation of

a map, the usual process of theory construction being compared to the traditional method of map making, and the development of the theoretical structure of the Reciprocal System being compared to the production of a map by aerial photography. Whatever the production process may be, either a map or a theory must be checked for accuracy before we can put any confidence in it, but the nature of the process of construction makes a big difference in the kind of a test that we apply. In testing a product of the traditional map making or theory construction processes it is necessary to verify each and every feature of the map or theory individually, as there is little or no connection between the individual features and, with relatively few exceptions, verification of any one feature does not guarantee the accuracy of any other. But in testing an aerial map or an analogous theoretical product such as the Reciprocal System, where the entire map or theory is produced in one operation by a single process, every test that is made by comparing the product with the observed facts is a test of the process itself, verification of the individual features selected for test being merely incidental. If anything that can definitely be seen on the map conflicts with anything that we positively know from direct observations of the terrain, then the process is not accurate and the map as a whole can be discarded.

On the other hand, since each check against the observed facts is a test of the accuracy of the process, every additional test that is made without finding any discrepancy reduces the mathematical probability that any such discrepancy exists anywhere on the map. Hence by making a sufficiently large number of correlations distributed over a substantial portion of the map the probability of the existence of any error can be reduced to a negligible level. The same is true of the Reciprocal System. When we check the theoretical conclusions of this system against the results of observation and measurement in thousands of different applications throughout an extremely wide range of physical phenomena and find no contradiction or inconsistency, then we have reduced the mathematical probability of any error in the basic structure of the system to the point where it is negligible.

In aerial photography we first complete the map and then, after the completed product is available, we verify its accuracy by making whatever checks against the results of observation may seem appropriate. From a purely logical standpoint there would be much in favor of following the same procedure in the physical area; that is, developing the theoretical

universe of the Reciprocal System, the RS universe, as we will hereafter call it for convenient reference, in complete detail, without any reference at all to the observed physical universe and then, after the theoretical product is complete, comparing the individual features of the RS universe with the corresponding features of the observed universe. As a practical matter, however, this procedure is not feasible, particularly in the initial presentation of the system, because of the enormous amount of detail involved. What we will have to do is to proceed with a step by step development of the consequences of the Fundamental Postulates of the system and, as each step is taken, compare the features of the RS universe defined by those consequences with the corresponding features of the observed physical universe.

It is essential to bear in mind, however, that all of the conclusions that are reached in the theoretical development refer to the theoretical RS universe, not to the physical universe. This would be obvious if we were able to complete our theoretical map of the universe in its entirety before we began the operation of checking it against experience, but the situation is not altered by the piecemeal procedure, which we find it necessary to follow. For example, when we arrive at the conclusion that sub-atomic particles are incomplete atoms, not constituents of atoms, this is not a conclusion about the actual physical universe, nor has it been reached by a consideration of the available knowledge concerning physical particles of this kind. It is purely a theoretical conclusion: something that necessarily and unavoidably follows if the Fundamental Postulates of the Reciprocal System are valid. The assertion that is here being made is that *in the theoretical RS universe* developed from these postulates by logical and mathematical processes, the theoretical entities corresponding to sub-atomic particles are incomplete atoms. This assertion is not subject to challenge unless it can be contended that there is a flaw in the logical development whereby it was derived from the postulates.

A similar theoretical development, which determines the features of the theoretical RS universe applicable to the particular field under consideration, is carried out in each section of the presentation in this and the other volumes of the series. In the discussion of these matters, frequent reference will be made to the fact that the Theoretical conclusions apply specifically to the RS universe, but this presentation would be much too awkward and unwieldy if we at

tempted to qualify all theoretical statements in this manner. It should therefore be emphasized in advance that every theoretical statement in the subsequent pages—every statement about what entities are theoretically present in the universe, how they are related, and what properties they possess—is a statement about the RS universe, whether or not it is specifically labeled as such.

In the second phase of the presentation, carried out in conjunction with the theoretical development, it will be shown that each and every one of the theoretical conclusions is consistent with all positively established facts. Here, again, it is important to keep in mind the exact nature of the undertaking. No attempt is being made to prove the validity of each of the theoretical conclusions individually. For instance, the presentation will offer no proof that sub-atomic particles are incomplete atoms rather than constituents of atoms; what it will do is to show that there are no positively established facts that are *inconsistent* with the hypothesis that this is the true status of the sub-atomic particles in the physical universe, just as it necessarily is in the theoretical RS universe.

The object of comparing the theoretical conclusion regarding the sub-atomic particles with the experimental and observational data is not to test the validity of this conclusion itself, an undertaking which is not feasible at present because of the lack of sufficient data of a specific and unequivocal character, but to test the validity of the hypothesis that the theoretical RS universe is identical with the actual physical universe. If there were any definitely known facts about the observed sub-atomic particles that could be shown to be inconsistent with the nature and properties of the corresponding particles in the RS universe, as deduced from the Fundamental Postulates, then the postulated identity of the theoretical and observed universes would be disproved. But since there is no such inconsistency, a certain degree of probability has been established for the identity hypothesis, regardless of whether or not any definite *agreement* can actually be demonstrated in this instance. Each additional comparison of the same nature is another test of the validity of the same hypothesis. If any contradiction or inconsistency is found in *any* of these tests, the identity is disproved. If no such discrepancy is found, then every additional test of this kind decreases the mathematical probability that any discrepancy exists *anywhere*. Hence by making a sufficiently large number and variety of similar tests, the probability that

the theoretical RS universe is not identical with the observed physical universe can be reduced to the point where it is negligible, which is one way of proving that the two are identical.

This proof that the observed physical universe is identical with the theoretical RS universe means that each and every feature of the physical universe exists exactly as portrayed by the theoretical development. Thus, while we do not submit any *individual* proof that sub-atomic particles are incomplete atoms, we prove collectively the validity of *all* of the theoretical conclusions derived from the postulates of the Reciprocal System, including the one that we have been using for purposes of illustration: the conclusion that sub-atomic particles are incomplete atoms.

The plan of presentation of the Reciprocal System in the several volumes of this series can thus be summarized as follows:

1. A theoretical universe is derived by developing the necessary consequences of the Fundamental Postulates of the system.
2. The identity of the theoretical RS universe and the observed physical universe is proved by comparing the corresponding features of the theoretical and observed universes in thousands of individual cases, and showing that there is no inconsistency between the two in any instance where the physical facts have been positively established.

It is evident from this that the status of previously existing theories has no bearing at all on the points at issue. The two numbered statements can be refuted only if (1) it can be shown that there is a logical flaw in the chain of deductions from the postulates, or (2) it can be shown that there is an inconsistency between the consequences of the theory and the established facts. Conflicts with previous theories have no relevance to either of these issues.

Under the circumstances it would be quite appropriate to present the new theoretical structure, and establish its validity in the manner indicated, without any reference at all to previous theories. This policy was followed, with only a few exceptions, in the initial volume of the series, *The Structure of the Physical Universe*. Experience has indicated, however, that comparisons with previous ideas have considerable value as an aid in gaining an understanding of the new concepts and theories, and for that reason the more recent books have devoted a substantial amount of space to discussing existing theory. It

is important to recognize that such discussion is merely for purposes of clarification, and has no place in the actual development of the primary thesis of this work. In particular, it should be understood that no issues are being decided on the preponderance of evidence.

Ordinarily, when a question such as that of the status of the sub-atomic particles arises, the relative weight of the evidence on each side is the basis on which a decision is made. The evidence for and against the theory that the sub-atomic particles are atomic constituents is gathered and evaluated, the same is done for the theory that these particles are incomplete atoms, and a decision is then reached in the manner of a verdict in a case in court. Such a decision is a judgment—an *opinion* as to which case is the stronger—and it is subject to all of the weaknesses of human mental processes as well as to the uncertainty that is inherent in conclusions based on interpretations of incomplete and often contradictory evidence. The program of this work, on the other hand, leads to a purely objective conclusion, in which opinion and judgment play no part. Definite and specific theoretical conclusions are compared with positively established facts and in each case the answer can be an unequivocal yes or no.

This obviously means that a great deal of care must be exercised in making certain of the authenticity of the supposed facts that are utilized for the comparisons. There is no justification for basing conclusions on anything that falls short of positive knowledge. In testing the accuracy of an aerial map we realize that we can not justify rejecting the map because the location of a lake as indicated on the map conflicts with the location which we think that the lake occupies. In this case it is clear that unless we actually know exactly where the lake is, we have no legitimate basis on which to dispute the location shown on the map. We also realize that there is no necessity for paying any attention at all to items of this kind: those, which are uncertain. There are hundreds, perhaps thousands, of features about which we do have positive knowledge, more than enough for purposes of comparison, so we do not need to give any consideration to features about which there is any degree of uncertainty.

The same is true in testing the validity of the Reciprocal System. There are thousands of places in all of the major fields of physical science where the pertinent facts are positively and definitely known; as in the case of the aerial map, more than enough for purposes

of comparison. Here again there is no justification for giving any consideration at all to features about which there is any degree of uncertainty. The reason for stressing this point so strongly is that so many of the items included in the current store of "knowledge" in physical science is not established facts at all but merely *interpretations* of the actual observations. The conclusions of the Reciprocal System conflict with a great many of these interpretations, but conflicts with "knowledge" of this kind are meaningless. There is no good reason why a new theoretical structure should be expected to agree with existing theories or with interpretations of experimental results based on those theories. Indeed, a correct theory *must* disagree with at least some of them; otherwise it could not succeed where they failed. The Reciprocal System is prepared to meet the test of conformity with all positively established physical facts. A correct theory can do no less, but neither can it do more; it cannot agree with both fact and error.

Many of the erroneous conclusions of present-day science have been generally accepted for so long a time that they are widely believed to be factual, and where items of this kind have been encountered in the development they have been given some attention in order to demonstrate their true status. It should be understood, however, that for present purposes it is not necessary to prove that these conclusions are wrong; all that is needed is to show that there is a reasonable doubt as to their validity. Where there is any substantial doubt as to the correctness of currently accepted ideas, any conflicts with the new system are meaningless; they have the same standing as the conflict between the position of the lake shown on the aerial map and the position which we *think* that the lake occupies.

This is an important point, as it is easy to demonstrate that many accepted ideas are mere assumptions, which have no factual basis, whereas it may be extremely difficult to *disprove* them. For example, there is a great deal of indirect evidence indicating that the commonly accepted explanation of the source of energy of the stars, the conversion of hydrogen to helium, is not correct, but to prove this point conclusively is not possible at present, because of the lack of direct information as to the conditions that exist in the stellar interiors. The subject of the stellar interiors, says Bonnor, "is an extremely difficult one because all that is really observed of stars is their exteriors, and from this the whole structure of the interior has to be inferred. As

Fred Hoyle once said, it is like trying to deduce the composition of a chimney sweep from the color of his skin."75 But this same lack of information is equally effective in reverse; it precludes proof of the affirmative position as well as the negative. Hence even the staunchest supporters of the hydrogen conversion theory have to admit that it is only a hypothesis. This means that if the Reciprocal System conflicts with the current theory of stellar energy generation — which it does — it is not in conflict with an established fact, which would be fatal; it is merely in conflict with a currently popular hypothesis, and this conflict has no actual significance one way or the other.

In view of the extraordinary importance attached to any one possible inconsistency between theory and fact in testing the Reciprocal System, it is essential to use an extraordinary degree of care in making certain that the alleged facts utilized for comparison are actually facts, not assumptions or interpretations masquerading as facts. When every test is a crucial test-one which can destroy the entire development if a definite inconsistency is found-then it is imperative that every test be a thorough and honest test. In principle every new theory is entitled to be evaluated in the most careful and painstaking manner, since new ideas are the most important raw material of scientific investigation, and if the human race habitually followed the logical and systematic procedures that we attributed to *homo super-sapiens* this policy would no doubt be carried out, but human science does not operate in this manner. The scientist who undertakes to evaluate a new theory of the usual kind knows from the start that the odds are overwhelmingly against it. The great majority of all new theories that are proposed are wrong in some essential respect, hence the evaluator does not expect that the particular new theory which he is examining will meet his tests, and he would be greatly surprised if it did. He therefore views his task more as a matter of locating and exposing the error which he feels certain exists in the new theory than as a matter of ascertaining whether or not there is any such error, and he is psychologically prepared to render a negative verdict as soon as some seemingly unfavorable bit of evidence appears, without taking the time and trouble to examine that evidence carefully and critically.

In the present instance, this kind of an examination is simply not adequate. Here the probabilities are completely reversed, and it would be very surprising if the theory does not meet the particular test that

is being applied. The postulates of the Reciprocal System are not mere assumptions on the order of the basic hypotheses of the usual physical theory, but have been derived by the reliable process of extrapolation of observed facts and hence have a strong probability of being correct. It is quite unlikely, the probability principles assure us, that any discrepancy will be found between the results obtained from this system and the true facts. Consequently there are, in this case, strong grounds for doubting the validity of anything that seems to contradict the validity of the theoretical conclusions. When we take this into consideration along with the extraordinary effect that any one inconsistency would have if it did exist, it is clear that any seeming conflict should be examined with the utmost care and thoroughness. The Reciprocal System admittedly conflicts with many tenets of present-day scientific doctrine, but it can be shown that these are not conflicts with established facts, and hence they have no bearing on the points at issue.

It is worth noting, however, that the conflicts with the current thought of the scientific profession are not nearly as numerous as might be expected from the basic nature of the new concepts that are being introduced. Surprising, as it may seem, in view of the drastic nature of these conceptual changes, the new system is in full agreement with the great bulk of existing physical theory. There are some rather spectacular conflicts with the so-called "modern" developments, to be sure, but in spite of the prominence that "modern physics" has acquired in recent years, these subjects in themselves represent only a relatively small part of the total field. Almost all of the theoretical relations applicable to our immediate environment which have been firmly enough established to enable the applied scientists—the engineers—to utilize them on a practical basis can be derived from the postulates of the Reciprocal System in essentially the same form in which they are now known. These relations—Newton's Laws of Motion, the gas laws, the laws of thermodynamics, the laws of optics, the kinetic theory, Newton's Law of Gravitation, Kirchhoff's Laws, Ohm's Law, Hess's Law, Faraday's Law, Avogadro's Law, Pascal's Law, and so on—are incorporated into the Reciprocal System practically intact. Where some change has been necessary, as in the laws of motion, this change has usually been in the definition of the concepts entering into the particular relation, rather than in the physical or mathematical expression of the relation itself. Newton's Laws of Motion, for instance, are retained in his original form, but the concept of time has been altered.

The new system is likewise in harmony with at least some of the original concepts and ideas of the so-called "modern" physics: those portions of modern theory, which are based directly on empirical findings. Planck's original theory of the quantum of radiant energy is fully compatible with the consequences of the postulates of the system, as is Einstein's extension of Planck's hypothesis to the photoelectric effect. The Lorentz transformations are likewise acceptable to the Reciprocal System and, as has been brought out in the preceding pages, this system and the Special Theory of Relativity are therefore in agreement mathematically, although the new information developed from this present investigation shows that the Special Theory is conceptually wrong.

Within the realm of everyday experience-the fields of the engineer, the chemist, the geologist, etc.,—the role of the Reciprocal System has been primarily a matter of filling in the gaps in existing knowledge. In such fields as that of chemical combination, for example, where existing theory is painfully inadequate, it has been possible to establish complete and correct theoretical structures. Furthermore, the new system has made a major contribution by extending the scope of theory to the *magnitudes* of physical quantities. Of course, previously existing theory covers the mathematical *relations* between physical quantities—indeed, the quantitative treatment is often regarded as the essence of science—but in general, these previous theories have not been able to account for the individual magnitudes. They have not been able, for example, to specify the magnitude of the gravitational constant, or the molar gas volume, or Planck's constant h, or the Faraday constant, and so on; it has been necessary to *measure* these quantities and to use the values thus determined.

Likewise, the theorists have not heretofore been able to devise any means whereby we can calculate from purely theoretical foundations (except in rare and very special cases) the numerical values of the properties of physical entities-such properties as density, specific heat, viscosity, refractive index, etc.—even though these properties do have definite magnitudes which clearly must be subject to some kind of physical laws. The development of the postulates of the Reciprocal System yields not only qualitative relations but also quantitative relations, and the absolute magnitudes, or at least the possible magnitudes, of such items as the foregoing can be derived from theory alone.

In the far-out regions the task of the new system has been to build a completely new theory. Here, where empirical knowledge has been too scanty and too confused to constitute any effective restraint on the imaginations of the theorists, previous theory constructors have attempted to explain the observed phenomena by pure speculation and *ad hoc* modification of the principles applicable to the more familiar regions, and as a result it is here that theoretical science is finding itself unable to keep up with the progress of experimental discovery. The Reciprocal System is not subject to the handicaps that conventional theory encounters in these less accessible regions, as this system derives its entire theoretical structure from a logical and mathematical development of the consequences of the Fundamental Postulates, and does not depend on guidance or assistance from observational or experimental information. By reason of this purely theoretical derivation, the new system has been able to arrive at complete and consistent theories covering the phenomena not only of those regions where observational data are meager, but also some other regions, which are still completely unknown observationally.

The most drastic *changes* made by the new system, as distinguished from additions to or clarifications of previous theories, come in these areas where scientists have, without being aware of the fact, made contact with regions of the universe other than the one in which we happen to be located and to which our familiar physical relations apply. It is here that the theorists have attempted the impossible; they have attempted to fit the relations appertaining to one region of the universe to the phenomena of other regions that are actually governed by totally different, and in some cases diametrically opposite, relations. And it is here that they have, as a direct consequence, found themselves in a state of confusion and uncertainty: a situation that is responsible for what Hanson calls "the agonies which now confound quantum theory and cosmology,"[76] and for the recurring "crises" in other physical fields.

In the light of the information developed in this present investigation it is clear that the existing confusion was inevitable. The theorists who have attacked these problems have lavished an immense amount of intelligence, ingenuity and perseverance upon them, but a problem cannot be solved, no matter how great the ability of those who undertake its solution, or how much effort they apply to the task, if the

basic nature of the problem is misunderstood. "The most interesting fact about laws of nature," says Michael Scriven, "is that they are virtually all known to be in error."[77] But this conclusion is not at all representative of the true situation; it is merely one of the results of the physicists' misconception of the nature of the phenomena with which they are dealing. Most of the so-called "classical" laws are correct in their proper sphere, and the "errors" that are commonly charged against them are simply consequences of attempting to apply them in areas which are governed by totally different relations.

As Freeman J. Dyson points out, some major innovation is required in order to "put an end to the present confusions"[14]—an "epoch-making" innovation, he says. The Fundamental Postulates of the Reciprocal System as developed by extrapolation of the observed properties of space and time in the preceding chapter now provide us with the kind of a conceptual innovation that is needed, and the remainder of this volume will be devoted to showing how the development of the consequences of these postulates brings order out of confusion in the unsettled areas of physical science.

This is an appropriate point at which to reiterate that the entire theoretical development rests upon these two postulates, without the introduction of *any* additional assumptions or any data from observation. In the next chapter it will be demonstrated that the existence of matter and of radiation are direct consequences of the postulates, and that the primary properties of these entities are specifically defined by the further development of these consequences. Chapter VII will then show that matter, which originates in this manner, must exist in the form of individual atoms, and that the possible structures of such atoms constitute a series which we can identify as a series of chemical elements. Further development of the consequences of the postulates, without reference to anything outside of the system defined by these consequences, then leads to a complete theoretical universe which, on comparison, we find to be identical with the observed physical universe.

The program that will be followed in the subsequent pages of this present volume will not involve complete development of any sector of the theoretical RS universe, but will merely trace the development far enough in each major physical field to indicate the general nature of the modifications which will be necessary in each of these areas

by reason of the new concepts of space and time which the theory introduces. As the theoretical structure is gradually erected, the way in which it clarifies hitherto obscure points and brings seemingly discordant observational data into harmony will be illustrated by a brief consideration of the appropriate phenomena. Details will, however, be held to a minimum, as the aim of this presentation is to give a bird's eye view of the new theoretical structure as a whole: one which will emphasize the unitary character of the system, the simple and logical nature of the explanations which it offers, and the complete agreement with the facts, including many that previous theories have been unable to cope with.

There is nothing surprising or unexpected about the fact that a theoretical system which is able to prove that it is correct in its entirety should be capable of providing simple and logical solutions for extremely difficult problems of long standing, as well as meeting the many less exacting demands that are made upon it. Such achievements are, however, very dramatic and conclusive demonstrations of the power and versatility of the new system, and for that reason they warrant some special attention over and above whatever comment may be made as to their contribution toward the general proof of the identity of the theoretical RS universe and the observed physical universe. In the ensuing discussion, therefore, we will specifically point out a number of the *Outstanding Achievements* of the Reciprocal System and will explain the significant contribution that each has made toward overcoming previously existing difficulties.

CHAPTER VI

Progression vs. Gravitation

From the standpoint of our accustomed habits of thought, one of the most surprising of the conclusions that were derived by the extrapolation process in Chapter IV is that of a progression of space. The somewhat intuitive impression that we gain from our everyday experience—an impression that has been accepted and formalized by present-day physical science—is that space is an entity that "stays put," whereas time is an entity that progresses. But now the postulate derived from an extrapolation of the observed space-time relation tells us that space also progresses in exactly the same manner as time.

The origin of the progression is evident as soon as the reciprocal postulate is formulated. If space and time are reciprocally related, then a single unit of space is equivalent to a single unit of time, from the scalar space-time standpoint. When the passage of one additional unit of time causes point A to move forward to A + 1 in time, the equivalence of the unit of time and the unit of space means that point A has also moved forward one additional unit of space, to point A + 1 in space.

The general nature of the progression is not as obvious. Our rather vague psychological impression of the passage of time suggests a unidirectional movement, from the past and toward the future–the River of Time, as it is so often called. But now that we recognize both space and time as progressing, we have an opportunity to see the progression in a much clearer light. As pointed out in Chapter IV, the recession of the distant galaxies is clearly due to the space-time progression, and this phenomenon therefore gives us a visible illustration of the nature of the progression of space and, by extension, the nature of the corresponding progression of time. It is not difficult to get a clear mental picture of the observed situation in which the galaxies are moving directly outward from us in all directions, and we need only to imagine this recession taking place at the velocity of light—which it undoubtedly does somewhere beyond our present

observational range—in order to get an understanding of how the *locations* in space are continually moving away from the location which we happen to occupy.

The corollary to this proposition, the fact that we are likewise moving away from all other galaxies in the same manner and that the location which our galaxy occupies is moving outward in all directions away from all other spatial locations, is somewhat harder to visualize. It is not easy to conceive of motion taking place in all directions simultaneously. But unless we wish to take the position that our galaxy alone, among all of the billions within observational range, occupies a fixed position—a rather fantastic contention—our galaxy *must* be moving away from all others, and hence must be moving in all directions. A motion in all directions has no *specific* direction; that is, such a motion is scalar. The movement is simply from A to A + 1 and on to A + n, both in space and in time. To illustrate this phenomenon the astronomers commonly utilize the example of points on the surface of a balloon, which is being inflated. As the inflation proceeds, the distances between the points gradually increase; that is, each point moves away from all other points, and thus moves outward in all directions simultaneously. By visualizing a similar situation in three dimensions we can obtain a mental picture of the recession of the galaxies and of the progression of space which causes the galactic recession.

If we now recognize that time is subject to exactly the same kind of a progression as space, we can get a new concept to replace the familiar idea of a "River of Time" flowing past us unidirectionally. Instead of a river, we should visualize the equivalent of an expanding balloon. Each point in time moves outward from all other points just as each point in the three-dimensional space occupied by the balloon moves outward from all other points. But we should keep in mind that the balloon is an incomplete analogy. The progression of time is different in one important respect: it does not take place in space; it takes place in time. Each location in time is continually moving outward away from all other locations in time.

An important consequence of the progression of space-time is that unit velocity, one unit of space per unit of time, is the condition of rest in the physical universe, the datum from which all activity begins. We are so accustomed to measuring from the mathematical zero that this concept of a finite velocity as the neutral condition will no doubt seem

odd on first consideration, but it is not without precedent. There are other physical situations in which the neutral point is at some finite value with meaningful deviations in both directions. For example, there is the hydrogen ion concentration, measured on the pH scale. If we are concerned about alkalinity and we find that two solutions have pH values of 7 and 8 respectively, it might appear to the uninitiated that one solution is slightly less alkaline than the other. The truth is, of course, that the solution with the 7 pH is not alkaline at all, as 7 is the neutral value. This is not an arbitrary point, like the zero on the Centigrade temperature scale; the pH is mathematically related to the actual hydrogen ion concentration, and hence represents an actual physical reality. Unit velocity is a neutral value of the same nature: a true physical datum with a finite magnitude.

In this neutral condition, each unit of space is exactly like all other units of space and each unit of space is equivalent to a unit of time that is exactly like all other units of time. A unit of elapsed time, a unit movement in time, is equivalent to a unit movement in space, hence all locations in space-time are moving away from all other locations at unit velocity. Since space-time is motion, in the most general sense of that term, its measure is speed or, as this speed manifests itself in a spatial or temporal reference system, velocity. Just as we measure space in centimeters, or some similar unit, and time in seconds, we measure space-time in centimeters per second–in velocity terms. Unit velocity is not only the measure of the progression of space-time; it is the measure of space-time itself. Space-time is a motion: a progression. Aside from this ceaseless progression, a universe in the neutral condition would be one vast domain of perfect uniformity in which nothing ever happens and nothing could happen.

In order that there may be *events* or *phenomena* in the universe—anything other than the uniform and featureless progression—there must be a deviation from unity: a displacement of space-time from the unit level. There cannot be any such deviation in the space-time velocity, since the equivalence of a single unit of time and a single unit of space holds good for any number of units or any combination of units. The space velocity or the analogous quantity in time may, however, experience displacement because of the directional effects that pertain to space and time individually. If the space direction of the progression, for example, reverses at the end of a unit, the progression of space-time is not affected,

since space-time is scalar and has no directional characteristics, but the progression of space now moves back over the same *space* unit which it just traversed.

On first consideration it may be hard to understand how an object which is moving directly away from us can reverse its direction of motion and still continue moving directly away from us. We realize, however, that inasmuch as the distant galaxies are all moving directly away from us, we must be moving directly away from *all* of them. Our galaxy M is therefore moving away from galaxy A in the direction AM, whereas it is also moving in the opposite direction BM directly away from some galaxy B which is diametrically opposite to A in our field of vision. It is quite possible, then, for some object to have a motion coinciding with the recession of our galaxy in the direction AM, and then to reverse this spatial direction and move in unison with the recession of our galaxy in the direction BM.

The important point here is that the recession of our galaxy in the direction AM moves the galaxy outward in space away from all other galaxies. Consequently any object whose motion coincides with that of the galaxy is also moving outward away from the distant galaxies; that is, it is moving outward from all other locations in space. But exactly the same thing can be said of any object whose motion coincides with that of the galaxy in the opposite direction BM. This object is also moving outward away from all other locations is space.

The scalar direction of any motion, the inward or outward direction toward or away from all other locations, is thus independent of the spatial direction. In the example we have been discussing, motion in the direction AM may be either inward or outward, from the scalar standpoint. The same is true of motion in the direction BM. This explains how the space-time progression which, in our region of the universe, always proceeds outward, can, under appropriate circumstances, reverse its spatial direction.

No special mechanism is necessary in order to accomplish this reversal. The reciprocal postulate requires the existence of aggregations of n units of space (or time) in association with single units of time (or space) and, as indicated in the foregoing discussion, a change of spatial direction (or temporal direction) is the only means by which such associations can be formed. Deviations from the normal one to one space-time ratio—*displacements* of space-time, as they are called

in this work—therefore *must* exist, and directional changes *must* take place wherever such displacements occur.

A directional reversal of this kind is an event—a physical occurrence—and it takes place at a specific spatial or temporal location. All such locations are subject to the progression; that is, a space-time location is a thing in motion. The reversed motion thus becomes detached from the general space-time structure and is carried along by the progression in a direction perpendicular to the direction of the original motion. It now becomes a physical entity: an independent phenomenon pursuing its own course and having a space velocity of its own, the magnitude of which is determined by the relative frequency of reversals of space direction and time direction. Space progresses n units while time progresses m units, and the space velocity is therefore n/m *in this particular phenomenon.*

Although we have been dealing only with reversals thus far, it will be noted that in making some of the general statements in the preceding paragraphs it was necessary to use the term "change" rather than "reversal" of direction. The reason is that there is no requirement of an immediate reversal. A gradual change of direction by means of a rotational movement will accomplish the same result. However, a direct generation of rotation from the neutral condition, in which nothing exists but the uniform progression of space-time, is impossible simply because there is nothing to rotate. The first effect of a displacement applied to the neutral situation is therefore to cause vibrational motion. The vibrating unit then progresses translationally as has been explained. When this vibrating unit is viewed from a reference system that does not progress, the combination of an oscillation in one dimension with a unidirectional progression in a perpendicular dimension takes the form of a sine curve.

If a number of such oscillating units are generated at the same space-time location–that is, are generated simultaneously at the same space location–their unidirectional progression always takes place in the outward scalar direction, but outward from the scalar standpoint is indeterminate from the standpoint of spatial direction, and the progression of any individual unit can therefore take any spatial direction. Since all directions are equally probable, the mathematical principles of probability, whose validity was assumed as a part of the Second Fundamental Postulate, tell us that the individual progressions

of the units will be distributed equally over all spatial directions. The first phenomenon that we develop from the Fundamental Postulates is therefore one in which oscillating space-time units originate at various locations in space-time and move outward in all directions from these locations at unit velocity, one unit of space per unit of time.

The various entities that emerge as constituents of the theoretical RS universe as the development proceeds will, of course, appear without labels, but it will not usually be difficult to identify the corresponding feature of the observed physical universe. In this case it is obvious that the oscillating units which we have been describing are *photons* of light or other electromagnetic radiation. The process of emission and movement of these photons is known as *radiation*, the space-time ratio of the oscillation is the *frequency* of the radiation, and unit velocity is the velocity of electromagnetic radiation or, as it is more commonly termed, the *velocity of light,* customarily represented by the symbol c.

Here, then, is the first of those *Outstanding Achievements* of the Reciprocal System, which deserve special emphasis. The foregoing description of the nature of the photon furnishes a complete and logical explanation of the seemingly paradoxical behavior of radiation in which it sometimes acts as a particle and sometimes as a wave—one of the most baffling enigmas of modern physics: "the vexed antinomy of 'corpuscles versus waves' which contemporary physics faces and which the term "complementarily" merely hides without removing,"[78] as Čapek describes it. The photon acts as a particle in emission and absorption because it is a single independent unit; it travels as a wave because the combination of a linear oscillation and a translatory movement in a perpendicular direction produces a wave-like motion.

One of the most significant features of the Reciprocal System is that the explanations, which it produces for basic physical phenomena, are extremely simple. Instead of explaining why seemingly complicated phenomena are complex and perplexing, this system removes the complexity and reduces the phenomena to simple terms. The space-time progression and the galactic recession, which it produces, occur because one unit of space is equivalent to one unit of time. The photon originates by a periodic reversal of the direction of one of the components of space-time. Both of these are about as simple as any physical explanation can be. Now we find that the answer to the seemingly insoluble wave-particle problem is equally simple. To the

question: Is the photon a wave, a particle, some hybrid that could be called a "wavicle", or is it one of the ghostly denizens of the half-world of the quantum theories?, we are able to reply: The photon is a particle (that is, a discrete physical entity) which travels as a wave. On this basis the reason why radiation can have wave-like properties such as that of polarization even though it consists of discrete particles is obvious.

The same simple explanation of the nature of the photon can also be credited with Outstanding Achievement Number Two: the answer to the problem of how the energy of radiation is transmitted from one object to another distant object without any connecting medium between the two. Such answers must be innovations; if they could be obtained from existing lines of thought there would be no problems. Furthermore, if they are to be simple answers to problems of long standing, they must have some rather surprising aspects, as it is not at all likely that answers within the bounds of accepted thinking would have remained hidden so long, particularly in view of all of the effort that has been applied to searching for them. In the case of the wave-particle problem, no one has previously realized that the photon, as observed, might be more than a photon; that is, it might be a photon in conjunction with something else. But as soon as we look at the situation in this light, it is apparent that we have arrived at a simple solution of the difficulty.

The innovation that solves the problem of how radiation is transmitted through empty space is one of an even more surprising character. The answer here is that radiation is not transmitted at all. The photon remains *permanently* in the same space-time location in which it originates, but space-time itself progresses, carrying the photon with it, and the photon is therefore able to act on any objects which are not carried along by the progression and which are therefore encountered en route. For an explanation of the nature of these objects, let us now return to the subject of rotation.

Once the photon has come into being, the previous obstacle to the existence of rotational motion has been eliminated, since there is now an "object" that can rotate, and our next step in the development of the theoretical RS universe will be to examine the characteristics of this rotation. First, let us bear in mind that the photon, the object which we are going to rotate, is itself a motion, so that when we rotate the photon what we are actually doing is generating a compound motion.

We cannot do this by simple addition, as a total magnitude exceeding that of the progression would result in a directional reversal, and would give rise to vibration rather than rotation. The photon can, however, rotate in the opposite scalar direction or, strictly speaking, since rotation has no meaning from a scalar standpoint, it can rotate in space or time in such a manner that the corresponding space-time movement is in the scalar direction opposite to that of the progression. Inasmuch as the space-time progression is linearly outward in space, this means that the scalar effect of the rotational motion is linearly inward in space.

Another requirement is that the magnitude of the rotational motion must be greater than that of the progression. One unit of inward motion would simply cancel the one unit outward movement of the progression and create the rotational equivalent of nothing at all. Less than one unit is not possible, as fractional units do not exist. Hence the magnitude of the rotational motion must be greater than unity. We find, then, that when the photon acquires a rotation it reverses its space-time direction and travels backward along the line of the progression, moving inward from its own location toward all other spatial locations.

Again we have no difficulty in identifying the corresponding phenomena in the observed physical universe. The rotating photons, with the exception of certain incomplete units that we will discuss later, are *atoms*. Collectively the atoms constitute matter, and their inward movement is *gravitation*.

As a rough analogy, we may visualize a moving belt, traveling outward from a central location and carrying an assortment of cubes and balls. The outward travel of the belt represents the progression of space-time. The cubes are analogous to the photons of radiation. Having no independent mobility of their own, they must necessarily remain permanently at whatever location on the belt they occupy initially, and they therefore move outward from their point of origin at the full velocity of the belt. The balls, however, can be caused to rotate, and if the rotation is in the direction opposite to the travel of the belt and the rotational velocity is high enough, the balls will move inward instead of outward. These balls represent the atoms of matter, and the inward motion opposite to the direction of travel of the belt is analogous to gravitation.

The analogy is, of course, incomplete. It cannot portray a strictly scalar motion, and consequently the mechanism whereby the rotation of the balls causes them to move inward translationally is not the same as that which causes the inward motion in the actual atomic situation. The analogy is also unable to demonstrate movement in all directions. Nevertheless, it does show quite clearly that under appropriate conditions a rotational motion can cause a translational displacement, and it also gives us a rough picture of the general relations between the space-time progression, gravitation, and the travel of the photons of radiation.

Unlike the space-time progression, which originates everywhere, and therefore remains constant irrespective of location, the gravitational motion originates at the location, which the atom happens to occupy. Since the atom is moving in opposition to the space-time progression it is continually passing from one space-time unit to another. The spatial direction corresponding to this scalar inward motion is indeterminate, and inasmuch as this direction is continually being redetermined because of entry into another unit of space-time, the effect of the probability laws is to distribute the motion equally over all directions. The fraction of the total motion directed toward any area A at distance d is then determined by the ratio of this area to the total surface area of a sphere of radius d. This ratio is inversely proportional to d^2, hence the gravitational motion decreases with distance in accordance with the familiar inverse square law.

As the foregoing discussion indicates, gravitation is a movement of the atom inward toward all space-time locations other than the one, which it occupies (momentarily). Thus it is inherently a motion of the individual atom or material aggregate relative to the general space-time framework. However, the only way in which we can recognize such a motion is by reference to some observable aggregate of matter, and since that aggregate also has a similar gravitational motion inward in space-time, what we actually observe is that the two material aggregates are moving inward toward each other. Quite naturally this has been interpreted as indicating that the two masses are exerting forces of attraction upon each other, and the great problem of gravitation has been to account for the observed characteristics of these "forces," which are most extraordinary and totally unlike those of forces encountered elsewhere in the physical realm. How can it be possible for one mass

to exert a force upon another distant mass instantaneously, without an intervening medium, and in such a manner that the force cannot be screened off or modified in any way?

The total inability of modern science to make any headway toward an answer to this question has been so discouraging to the scientific profession that it no longer tries to find the answer. The current practice is to ignore the observations and to base gravitational theory on assumptions which are in direct contradiction to the observed facts. Even though all practical gravitational calculations, including those at astronomical distances, are carried out on the basis of instantaneous action, without introducing any inconsistencies, and even though the concept of a force which is wholly dependent upon position in space being propagated through space is self-contradictory, the theorists take the stand that since they are unable to devise a theory to account for instantaneous action, the gravitational force must be propagated at a finite velocity, all evidence to the contrary notwithstanding. And even though there is not the slightest independent evidence of the existence of any medium in space, or the existence of any medium-like properties of space, the theorists also insist that since they are unable to devise a theory without a medium or something that has the properties of a medium, such an entity must exist, in spite of the negative evidence.

As usually happens when men are driven, in the depths of their frustration, to the desperate step of denying the facts, all this has accomplished nothing. Gravitation is still an "enigma" or a "mystery" to the present-day scientist, and there is no indication that it is becoming any less enigmatic or less mysterious. Nor is any blue sky visible on the far horizon. Sir John Cockcroft summarizes the current (1964) outlook as follows: "It will probably be a long time before we can bring the gravitational forces within a general theory, since there is at present no progress in this direction."[79]

The answer, which the Reciprocal System now provides for this difficult gravitational problem is Outstanding Achievement, Number Three. The explanation in the preceding paragraphs not only tells us how gravitation originates and why it is an inherent property of matter, but also accounts for all of the seemingly strange properties of gravitation in the exact form in which they are observed. And here again a surprising innovation emerges. The new system does

not explain how one mass can exert a force on another distant mass instantaneously and without an intervening medium; it tells us that the reason for all of these peculiar properties is that gravitation is not an action of one mass upon another at all. Each mass unit is pursuing its own individual course entirely independent of all other masses, and the phenomenon that appears to be a mutual attraction is actually the result of the inherent nature of the individual motions. The gravitational motion of each mass is an inward scalar motion in opposition to the space-time progression, and it carries the mass inward in space-time. Since all other masses are similarly moving inward in space-time, each mass moves toward all other masses. Such a motion needs no medium, nor does it require a finite time for propagation; the inward motion is an inherent property of the atoms and there is no propagation.

We must now qualify the previous statement that the magnitude of the rotational motion of the atom is greater than that of the space-time progression by noting that this statement applies specifically to the situation at unit distance. Within this distance the net inward motion (or equivalent) becomes still greater because of the effect of the inverse square relation, outside this distance the net inward motion decreases for the same reason, and at some point in this outer region an equilibrium between the inward gravitational motion and the outward motion of the space-time progression is reached. Beyond this point the net movement is outward, the outward excess increasing as the distance becomes greater. Where an aggregate of matter is involved rather than a single atom, the gravitational motion is proportional to the mass, for reasons that will be explained in Chapter XII, and the point of equilibrium, the *gravitational limit,* as we will call it, is therefore a function of the mass.

We could include the distance factor in the analogy of the moving belt by devising some means of varying the speed of rotation of the balls with the distance from the central point. Under this arrangement the closer balls would still move inward, but at some point farther out there would be an equilibrium, and beyond this point the balls would move outward.

The reason for the great difference between the view that we get of time and the view that we get of space in our everyday experience is now evident. The progression of time is unchecked in our local environment

and this progression so far overshadows any other change in time location that it is the only aspect of time, which we observe. Space actually progresses outward at the same rate as time, but the outward motion which the space progression imparts to objects existing in this local environment is more than counterbalanced by the inward movement due to gravitation, and the net result is that what we seem to see is a stationary space in which most physical objects, aside from the photons of radiation, have relatively low velocities of a random character. Gravitation is thus the controlling factor in our view of the universe. In the local region where it overpowers the progression, we get a picture of a relatively stable environment; at great distances where the gravitational motion is small and the progression is dominant we get an entirely different picture: one in which all objects are moving apart at enormous speeds.

In view of the important role, which the galactic recession plays in cosmology, we are justified in characterizing the explanation of this recession that is provided by the new system as Outstanding Achievement Number Four. However, the existence of a gravitational limit, within which there is a net inward gravitational motion and outside of which there is a net outward progression, explains a great deal more than the recession of the distant galaxies. For one thing, it reconciles the seemingly uniform distribution of matter in the universe with Newton's Law of Gravitation and Euclidean geometry. One of the strong arguments that has been advanced against the existence of a gravitational force of the inverse square type operating in a Euclidean universe is that on such a basis "The stellar universe ought to be a finite island in the infinite ocean of space,"[80] as Einstein puts it. Observations indicate that there is no such concentration. As far as we can tell, the galaxies are distributed uniformly or nearly uniformly throughout the immense region now accessible to observation, and this is currently taken as a definite indication that the geometry of the universe is non-Euclidean.

It is now clear that the flaw in this argument is that it rests on the assumption that gravitation is effective throughout space. This present work shows that this assumption is incorrect, and that there is a net gravitational force only within the gravitational limit of the particular mass under consideration. On this basis it is only the matter within the gravitational limit that should agglomerate into a single unit,

and this is exactly what occurs. Each galaxy is a "finite island in the ocean of space" within its gravitational limit. The existing situation is thus entirely consistent with Newtonian gravitation operating in an Euclidean universe, which is the situation envisioned by the Reciprocal System.

The existence of the gravitational limit also solves the problem of how the galaxies could form in the first place, a question, which the cosmologists have been unable to answer. As Gold and Hoyle describe the situation: "Attempts to explain both the expansion of the universe and the condensation of galaxies must be very largely contradictory so long as gravitation is the only force field under consideration. For if the expansive kinetic energy of matter is adequate to give universal expansion against the gravitational field it is adequate to prevent local condensation under gravity, and vice versa."[81] In the RS universe gravitation is not the only force involved, and the existence of an equilibrium point within which the motion of matter is inward and beyond which it is outward accounts in an easy and natural way for both the aggregation of matter into galaxies and the recession of the distant galaxies.

The answer to the dilemma described by Gold and Hoyle could well be considered another of the outstanding achievements of the new system, but the limitations which have had to be imposed on the scope of this volume will prevent going into sufficient detail to clarify the nature of the process of galaxy formation, as it occurs in the RS universe, and this subject will therefore be omitted from the list. It should be understood in this connection that this list is not intended as a complete catalog of the major achievements of the Reciprocal System; it is merely a selection of the most significant items from among those included in the subject matter of this particular volume.

A full development of the other consequences of the existence of gravitational limits is also beyond the scope of this present volume, but it should be mentioned that these limits apply to all aggregates of matter and not only to the galaxies. Inasmuch as the smaller aggregates are under the gravitational control of the larger units such as the galaxies, the effect of the gravitational limits is somewhat modified in application to the smaller masses, but nevertheless, the existence of these limits has many significant results, some of which have been explored in previous publications.

CHAPTER VII

Compound Motion

The process whereby the compound unit of motion that we call an atom is produced by applying a rotational motion to a previously existing vibrational motion, the photon, is typical of the manner in which the complex phenomena of the universe are built up from simple foundations. We start with the motion of the progression: a uniform linear, or translational, motion at unit velocity. Then by introducing a displacement and thus altering the space-time ratio we create a vibrational motion. Next the vibrating unit is caused to rotate. The addition of this motion of a different type alters the behavior of the unit–gives it different properties, as we say in the vernacular of science–and puts it into a new physical category.

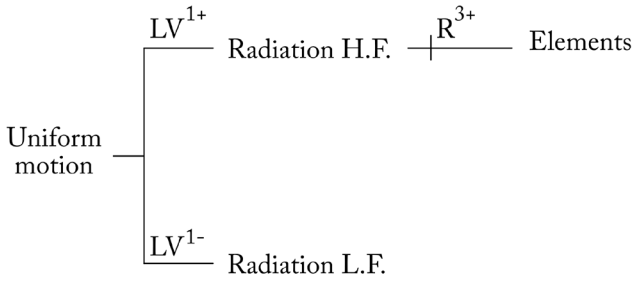


Chart A

All of the more complex physical entities with which we will deal in the subsequent pages are similarly built up by compounding the simpler motions previously existing. In order to facilitate following the explanation of this process as it will be presented item by item in the discussion, Chart A has been prepared to show the development that has taken place thus far, and more extended versions of the same chart, showing the successive additions to the original combinations, will be introduced at appropriate points in the pages that follow.

The factor which makes the great proliferation of these physical entities possible in spite of the fact that only one component–motion–is available for their construction, is the wide variety of forms in which this motion can exist, because of the directional freedom introduced by the three-dimensionality of space and time. First, there is a distinction between two general geometrical types of motion: (1) rotational (R) and (2) linear or translational (L). Then in addition to unidirectional motion of these two types, which we will designate by the symbols as shown, there may also exist vibrational motion of either type; that is, motion which is otherwise similar but which reverses direction periodically. For these we will use the symbols RV and LV. Furthermore, some of these motions can exist coincidentally in more than one dimension. Thus we may have a unit rotating in only one dimension (R^1), another similar unit rotating in two dimensions (R^2), and still another rotating in three dimensions (R^3). Finally, there is a substantial difference in behavior (properties) between velocities, which are above unity (multiple units of space associated with single units of time), and those, which are below unity (multiple units of time associated with single units of space).

The matter of terminology presents some problems here. We will apply the term positive (+) to high velocity vibration (high frequency radiation) and the term negative (-) to low velocity vibration (low frequency radiation). The direct rotational additions to the photons of radiation must have the opposite space-time direction, as previously noted, and there are some cogent arguments in favor of recognizing this reversal in the terms that are applied, but in order to avoid confusion it seems advisable to follow established precedents, and the rotational additions to the positive vibration will therefore be designated as positive in this work. Thus a material atom consists of R^{3+} superimposed on LV^{1+}. On the basis of this usage, the term "positive" is identified with the normal sequence of additions in the material system, rather than with a specific space-time direction.

The concept of physical entities as compound motions is one of the greatest contributions which the Reciprocal System makes toward the clarification of the physical picture, and it is one which is particularly significant because the existing situation in the atomic and "elementary particle" fields is nothing short of chaotic. Present opinion is that the atom is a composite of smaller units. This idea

originates primarily from the observation that, under appropriate conditions, atoms disintegrate, and in the process smaller particles make their appearance. Although it is now generally admitted that the particles which emanate from the disintegrating atom do not have the properties which atomic constituents, if there are any such, must necessarily possess, the observed disintegration is nevertheless accepted, in current scientific thought, as proof that the atom is composed of "elementary particles." As pointed out in *The Case Against the Nuclear Atom,* what we have here is the strange contention that the emergence of certain particles from the disintegrating atom is proof that the atom is composed of certain other particles.

Furthermore, no clue has ever been discovered as to the nature and origin of the force that holds the "parts" of the atom together, if any such parts exist, even though an enormous amount of time and effort has been devoted to searching for some kind of an explanation, "probably more man-hours than have been given to any other scientific question in the history of mankind,"[82] we are told. The only recourse thus far has been to fall back on an *ad hoc* postulate that a "nuclear force" exists for this specific purpose and nothing else. This is identical, except in the method of its expression, to the solution, which our primitive ancestors found for the difficult problems with which they were faced. The purely hypothetical "nuclear force" invented to hold the "parts" of the atom together for the baffled physicist is exactly the same kind of a thing as the "demon" that would have been invented for the same purpose in an earlier era, had the question arisen then.

In principle, modern science scorns the appeal to the supernatural by which primitive man tried to explain the unknown, but a purely hypothetical force invented *ad hoc* and totally lacking in any independent evidence of its existence is no less supernatural than any spirit or demon. It is simply a demon by another name. "There is a strong hint," says Fred Hoyle, "that what modern man has tried to do with the universe is no better than what primitive man did with problems whose nature we now find simple."[83]

If it could legitimately be claimed that the situation is improving and that science is definitely moving closer to a logical explanation of the atomic and sub-atomic relationships, there might be some justification for believing that current theory is on the right track, in spite of its

many defects and inconsistencies, but experimental progress has dealt a whole series of body blows to current ideas in recent years. One very embarrassing development is the ever-increasing number of "elementary" particles, which has now reached the stage where, as Henry Margenau expresses it, the word "elementary" has become the equivalent of "perplexing," "enigmatic," etc.[84] This, in itself, is a clear indication that the true role of the particles of modern physics is something other than that of "parts" of atoms.

However, the most devastating discovery of recent years is that there are no permanent "building blocks" of the kind that current theory visualizes as the ultimate constituents of the atoms of matter. The prevailing atomic and particle theories were developed on the assumption that the universe is constructed of a number—just how large a number has always been quite indefinite—of these permanent and distinctive "building blocks," basic entities of one kind or another, and that the manifold aspects in which natural phenomena occur are simply the result of combining these basic entities in different proportions and in different forms of construction. Experience with the high energies now available to the experimenters has disclosed, however, that nothing is permanent. These presumably distinctive "building blocks" are breaking down, recombining, and exchanging identities in a manner that, as Robert Marshak admits, is "extremely disconcerting"[85] to the present-day physicist. It is by this time firmly established that all of the basic physical entities—atoms, particles, radiation, translatory motion, electric and magnetic charges, etc.—are interchangeable. It may not always be possible to convert entity A into entity B directly, but the indications are that such a conversion can be accomplished by means of an indirect, if not a direct, process.

The present situation, then, is that the atom can be subdivided, but none of the products of that subdivision, nor any other known particle, has the characteristics which would qualify it to be a constituent of the intact atom, unless with the help of a "demon." It is also clear, on the basis of the information now available, that there is some common denominator underlying not only atoms and particles, but radiation and even translatory motion as well, and it is equally clear that none of the observed particles can qualify as this common denominator. The place of these particles in the physical picture is thus a complete mystery so far as present-day physics is concerned.

An even greater mystery is why the complete collapse of the "building block" theory of the function of the sub-atomic particles under the impact of modern experimental discoveries is not more generally recognized. Even the great tenacity with which the human mind holds to cherished ideas of long standing is hardly sufficient to explain retention of the current concepts and theories of atomic and particle physics in the face of the overwhelming evidence that these ideas are completely in error in almost every detail. The faith which the physicists still place in these battered and threadbare concepts is all the more remarkable since it is freely conceded that "drastic" changes will be required in the "fundamental ideas" of current theory, which, after all, is just another way of saying that the existing situation is hopeless and that we must have a new structure of theory. Consider these statements, for example:

From Sir George Thomson–

> There is some new idea wanted to make these new pieces fall into place in the puzzle … When the idea comes it may very probably involve a recasting of fundamental ideas and the abandonment of something that we now take completely for granted.[86]

From Freeman J. Dyson–

> For the last ten years it has been clear to most physicists that a basic conceptual innovation will be needed in order to come to grips with the properties of elementary particles.[14]

From P. A. M. Dirac–

> There (in dealing with the new particles) the theory is still in a primitive stage. It is fairly certain that there will have to be drastic changes in our fundamental ideas before these problems can be solved.[4]

From Norbert Weiner–

> There is a general feeling that the multiplicity of fundamental particles in physics is intolerable and is bound to be replaced in the near future by a much more unified physics in which both quantum theory and relativity are to be recast.[87]

From the standpoint of the present discussion, the most significant feature of these statements is the unanimous recognition of the fact that the situation is so serious that heroic measures are required; that "fundamental" and "basic" ideas must be changed. Modern "particle" theory is bankrupt. It is no wonder, then, that the process of

extrapolation, which is a far more reliable method of deriving the basic hypotheses needed for the construction of a theory than anything that was used in the development of the previously existing ideas that are now in such a sorry state, leads us to a totally new concept of the structure of the atom and an equally novel concept of the nature of the sub-atomic particles. We could not logically expect anything else, in view of the situation portrayed in the foregoing quotations. How else could we get a "recasting of fundamental ideas," a "drastic change," or a "basic conceptual innovation?" The complete lack of resemblance between the new theory and the old should occasion no surprise; all of the indicators clearly pointed in this direction long in advance.

Nor should it be in any way surprising, in view of the inherently strong probability that the extrapolated conclusions are correct, when the new theory overcomes, in an easy and natural way, all of the obstacles that loomed so large to its predecessors. Here is Outstanding Achievement Number Five. No longer is it necessary to invoke the aid of spirits or demons—or their modern equivalents: mysterious hypothetical "forces" of a purely *ad hoc* nature—to explain how the parts of the atom hold together. There is nothing to explain because the atom has no separate parts. It is one integral unit, and the special and distinctive characteristics of each kind of atom are not due to the way in which separate "parts" are put together, but are due to the nature and magnitude of the several distinct motions of which each atom is composed.

At the same time, this explanation of the structure of the atom tells us why such a unit can expel particles or disintegrate into smaller units even though it has no separate parts; how it can act, in some respects, as if it were an aggregate of sub-atomic units even though it is actually a single integral entity. Such a structure can obviously part with some of its motion or absorb additional units of motion without in any way altering the fact that it is a single entity, not a collection of parts. When the pitcher throws a curve ball, it is still a single unit—it is *a* baseball—even though it now has both a translational motion and a rotational motion, which it did not have while still in his hand. We do not have to worry about what kind of a "force" holds the rotational "part," the translational "part" and the horsehide covered "nucleus" together.

There has been a general impression that if we can get particles *out* of an atom, then there must be particles in atoms; that is, the atom

must be constructed of sub-atomic particles. This conclusion seems so natural and logical that it has survived what would ordinarily be a fatal blow: the discovery, as previously mentioned, that the particles which *emanate from* the atom in the process of radioactive disintegration do not have the properties which are required in order that they may be *constituents of* the atom. Three kinds of particles are ejected from the disintegrating atom. The gamma particles are photons, units of radiation, which have never been visualized as possible atomic constituents. The alpha particles are charged helium atoms, and it is generally conceded that they are not suitable elementary "building blocks." The beta particles are electrons. While current theory looks upon the electron as one of the atomic constituents, the present viewpoint is that the electrons emitted in radioactivity were not present as such in the preexisting atom but were created in the act of emission. Furthermore, the properties which an electron must have in order to be a constituent of an atom are totally unlike the properties of the electron that is actually observed. The whole concept of an atom constructed of "parts" thus bogs down in confusion.

It is now apparent that all of this confusion has resulted from the wholly gratuitous, but hitherto unquestioned, assumption that the sub-atomic particles have the characteristics of "parts"; that is, they exist as particles in the structure of the atom, they require something in the nature of a "force" to keep them in position, and so on. When we substitute *motions for parts,* in accordance with the conclusions of the Reciprocal System, the entire situation automatically clears up. Atoms are compound motions, sub-atomic particles are less complex motions of the same general nature, and photons are simple motions. An atom, even though it is a single unitary structure without separate parts, can eject some of its motion or transfer it to some other structure. If the motion which separates from the atom is translational, it reappears as translational motion of some other unit; if it is linear vibration, it reappears as radiation; if it is a rotational motion of less than atomic complexity, it reappears as a sub-atomic particle; if it is a complex rotational motion it reappears as a smaller atom. In any of these cases, the status of the original atom changes according to the nature and magnitude of the motion that is lost.

The explanation of the observed interchangeability of the various physical entities is now obvious. All of these entities are forms of motion or combinations of different forms, hence any of them can be

changed into some other form or combination of forms by appropriate means. *Motion is the common denominator of the physical universe.*

In the past there has been considerable speculation about the possibility that energy might have such a status; that all-physical entities might in some way be merely different forms of energy. In a sense this is true, as wherever there is motion there is energy. But energy is a scalar quantity, and it does not have the capability of being subdivided into the multiplicity of distinct categories that are required in order to account for the great variety of physical phenomena. It is true that there are subdivisions such as kinetic energy, electrical energy, etc., but these are merely auxiliary classifications; they play no part in the *measurement* of energy. An erg is an erg, whether it is a kinetic erg or an electrical erg. Motion, on the other hand, is vectorial, and all of the infinite variety resulting from its three-dimensionality is reflected both in the qualitative and the quantitative relations. A unit of vibrational motion is not fully equivalent to a unit of rotational motion. But it can be converted to a unit of rotational motion by appropriate processes.

The reasons for the existence of certain limitations on the transformations of this kind are practically self-evident. A structure requiring a total of n units of motion cannot be formed from a single unit containing less than n units, a rotating unit cannot be formed from purely translational units unless the equivalent of a mechanical couple is available, a very complex structure cannot be formed by a single process, and so on. But any physical structure can be broken down into simple units of motion, and under suitable conditions, any possible structure can be built up from simple units of motion, as all physical structures are constructed entirely of the one entity: motion.

As indicated in the foregoing discussion, the observed sub-atomic particles—neutrons, electrons, etc.—are not parts from which atoms are constructed; they are complex motions of the same general character as the atoms, but with a lower degree of complexity. The term "sub-atomic particle" is still quite appropriate in this new context and it will be retained in this work, but the term "elementary particle" must be discarded. There are no "elementary" particles in the sense of basic units from which other structures are constructed. The particle is smaller and less complex than the atom, but it is by no means elementary; the elementary unit is the unit of motion.

The place which the sub-atomic particles occupy in the hierarchy of motions can easily be identified by a further consideration of Chart A. As that chart indicates, the atom is a structure with a three-dimensional rotation; that is, rotation is taking place around all three of the mutually perpendicular axes. But it is not essential that rotation be three-dimensional. It can equally well be two-dimensional or one-dimensional. In fact, one-dimensional rotation is more familiar in our everyday world than any other. Chart A therefore needs to be modified to provide a place for rotation in less than three dimensions. Chart B shows how the system looks after this addition.

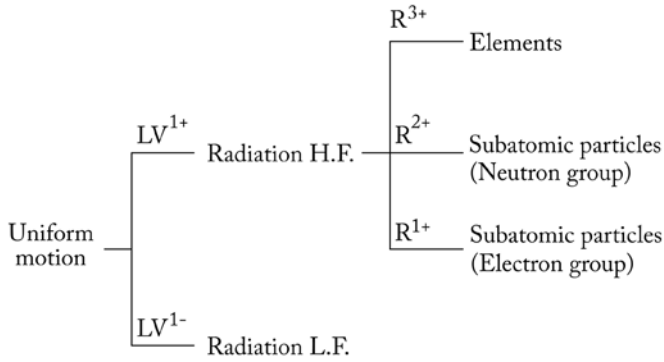


Chart B

Each added dimension of rotation alters the behavior of the rotating units—changes their properties—and the three groups of rotating particles are therefore easily distinguished physically. The most striking difference is that between the three-dimensional unit, the atom, and the sub-atomic units. A full consideration of the effect of the various types of rotation on the properties of the rotating units is beyond the scope of this volume, but it is evident from the points brought out in Chapter VI that one unit cannot enter into a permanent relation with another unit unless the rotational forces are effective in all three dimensions. The sub-atomic particles therefore have more of a temporary and evanescent character than the atoms. The differences between the two-dimensional and one-dimensional units are less obvious, but can be identified on closer study.

In the detailed development of the characteristics of the atomic and sub-atomic rotations of the material type carried out in an earlier publication it was shown that there are 117 possible three-dimensional

rotational combinations, three two-dimensional units, and two one-dimensional units. The one-dimensional units are the electron and the positron. The two-dimensional units are the neutron, the neutrino, and a particle, which has not yet been identified because it closely resembles the hydrogen atom and probably changes spontaneously to the hydrogen status. The 117 three-dimensional units are, of course, the known chemical elements plus a few additional elements beyond the end of the list of those thus far identified, elements that are unstable in the local environment.

Anyone who examines Chart B carefully will no doubt observe that there is a wide open space in this chart which clearly calls for another set of rotating units based on low frequency (negative) radiation rather than on the high frequency (positive) radiation which is the foundation for the rotational combinations that have been enumerated in the preceding paragraph. Such negative units actually do exist, and in due course the chart will have to be expanded accordingly. However, the rotation of these negative photons is also negative, in accordance with the principle previously stated, and this negative rotation, opposite in space-time direction from the rotation of the material atoms and sub-atomic particles that we have been discussing, gives these units some special properties in the local environment, and it will therefore be advisable to postpone discussion of these units until after we have laid a foundation for an understanding of these unusual properties.

There are two points about the subject matter of this chapter, the development that is portrayed graphically in Chart B. that deserve some special attention before we pass on to something different. First, it should be noted that this development goes a long way toward proving the validity of the two Fundamental Postulates of the Reciprocal System. As the preceding discussion shows, the status of the primary physical entities—atoms of matter, photons of radiation, sub-atomic particles, etc.—as compound motions is a direct consequence of the postulates, and this new concept of the nature of these entities turns out to be extremely successful, explaining in an easy and natural way all of the behavior characteristics that have given previous theories so much difficulty. Furthermore, the specific kinds of physical units that must necessarily exist if space and time actually have the properties that have been postulated are just the kinds of units that are observed in the physical universe. This cannot be a mere coincidence. It is

obviously highly improbable that the existence of exactly the kinds of units that the postulates call for, with exactly the type of behavior that the postulates require could be a matter of pure chance, and even at this early stage of the development, therefore, the odds in favor of the validity of the new theoretical system, already high to begin with, because of the strong inherent probability that conclusions reached by extrapolation from the known to the unknown are valid, have been greatly increased.

The second point worthy of comment is that all of the Outstanding Achievements and other accomplishments of the Reciprocal System that have been discussed thus far—the explanations for the existence of radiation, of matter, of sub-atomic particles, and of gravitation, the elimination of any need for an *ad hoc* demon or force to hold the atoms together, the new light which these explanations throw on such subjects as the recession of the distant galaxies, the formation of galaxies, the physical nature of the so-called "elementary" particles, the interchangeability of the various physical entities, etc.–have been entirely non-mathematical, and the results are such that they could not have been achieved by any kind of mathematical manipulation, however sophisticated and powerful the mathematical procedures might be. What was needed was a conceptual clarification: a correction of errors in the basic concepts previously utilized. There is "magic" in words, after all.

CHAPTER VIII

Motion in Time

In terms of present-day thinking, motion is regarded as a process-taking place in space: a change in the spatial relation between objects. But if space and time are symmetrical, as the reciprocal postulate requires, then it is equally possible for the temporal relations: between objects to undergo similar changes, and this process of temporal change constitutes motion in time.

The factors involved in the concepts of location in space and location in time have been examined in detail in previous publications, but since they are essential to an understanding of motion in time, we will review them briefly here. Let us first consider a distant galaxy, which at time t0 occupies location A in space, and is therefore receding from our Milky Way galaxy M, in the direction MA. During an interval t, the recession carries the galaxy outward in this direction to a new location B. But we know from observation of the nearer galaxies that these units also have random motions of their own, so that during time t the galaxy under consideration will have moved an additional distance to some location C which will not, unless by pure chance, lie on a prolongation of the line MAB. The actual displacement of the galaxy during time t is therefore the vector resultant of the distance AB and the distance BC.

We have already identified the recession of the galaxies as a manifestation of the progression of space, hence in view of the symmetry between space and time, we may deduce that exactly the same kind of a situation exists in time. While time is progressing from time location a to time location b, carrying a galaxy — our Milky Way galaxy, let us say — with it, the random motion of the galaxy in time takes it to some other time location c, and the total time displacement of the galaxy during this interval is not the time of the progression alone, but the vector resultant of this time ab and the random time displacement bc.

The progression of time which carries our galaxy from time location a to time location b is the quantity which we measure by means of a clock,

and it is commonly called *clock time*. Since the progression of space that carries the distant galaxy from location A to location B is the space equivalent of clock time we may utilize the same terminology and call it *clock space*. The random motion of the distant galaxy from location B to location C takes place in the ordinary three-dimensional space of our everyday experience, and inasmuch as we usually represent this by some sort of a coordinate system, we may call it *coordinate space*. The displacement of our galaxy from time location b to time location c is the time equivalent of the space displacement BC, and it takes place in three-dimensional time. Again we may use the same terminology that we apply to space and refer to this as *coordinate time*.

Because the gravitational motion cancels the motion of the space-time progression in our local environment we do not detect the recession of our own galaxy and the only space that we recognize locally is coordinate space. When we observe, for instance, that our near neighbor among the stars, Alpha Centauri, is moving away from us with a radial velocity of approximately 20 km/see, this is a motion in coordinate space, the same kind of a motion that we observe in our everyday life. When we also observe that a galaxy in Ursa Major is moving away from us with a radial velocity of 15000 km/sec, it would appear on first consideration that this is exactly the same thing, aside from the substantial difference in the speed. But in reality there is a very significant difference between the two motions. The motion of Alpha Centauri that takes it away from us carries it *toward* any star located still farther away in this outward direction. Unless one is familiar with recent astronomical discoveries, he is quite likely to take the stand that this must *necessarily* be true. The fact is, however, that it is *not* true in the case of the motion of the distant galaxies. When the Ursa Major galaxy moves away from us, it is also moving *away* from all other galaxies, including those located diametrically opposite from us.

Obviously these are motions of a totally different nature. The explanation is that the galactic recession is not a motion in coordinate space, the kind of a motion with which we are familiar. Aside from a relatively slow motion of a random character, comparable to the motions which we observe in the galaxies of our local system, the Ursa Major galaxy remains stationary in coordinate space but it moves outward in clock space. Our own Milky Way galaxy is doing exactly the same thing but, of course, we do not recognize our own outward motion from direct observation. Because of the reciprocal relation between space

and time the galaxies which move outward in clock space are moving inward in clock time, but here again the motion is outside the range of existing observational facilities.

In the local environment, where the gravitational motion exceeds that of the progression, the directions of motion are just the reverse. While the atoms of matter are moving inward in space under the influence of gravitational forces and thus gathering into aggregates that are localized in space, they are coincidentally moving *outward* in time in random directions. Hence the material aggregates are *not* localized in time; that is, the atoms of a star, for example, are clustered together in a stable configuration in a relatively small amount of space, but they are widely dispersed in time with no stable relationships between units. In our observation of time, therefore, we have no landmarks by which we can recognize positions in coordinate time, and the existence of this kind of time therefore remained undetected until it was discovered theoretically in this present investigation. The temporal relations between atoms occupying widely separated locations in time are comparable to the spatial relations between distant galaxies, and the aspect of time that is recognizable in our local environment is the clock time.

But even though the local situation is such that we normally recognize only clock time and coordinate space, clock space and coordinate time have some very significant effects under what we consider extreme conditions. At extreme distances the space progression, the motion in clock space, manifests itself as the recession of the galaxies. At extreme velocities the motion in coordinate time manifests itself by the deviations from Newton's Laws of Motion that were revealed by the Michelson-Morley experiment. Under conditions of extremely small space or time separations there is a replacement of motion in space by motion in time and vice versa which has some important effects that will be discussed later in this chapter.

The expression "motion in time," as it will be used in this work, refers to motion in coordinate time: a change of location in three dimensional time analogous in all respects to the change of location in three-dimensional coordinate space which constitutes motion in space. The *total* time corresponding to any specific clock time is the vector resultant of this coordinate time and the corresponding clock time.

The quantitative measure of motion in space is velocity, and the mathematical definition of velocity is $v = s/t$. Here the term s is a vector

quantity representing the displacement in space. The term t is scalar, since time has no direction in space, and the term v is then a vector quantity representing the space displacement per unit of time. The analogous quantitative expression for motion in time is $\Lambda = t/s$ or delta is equal to t divided by s. Here the term t is a vector quantity representing the displacement in time. The term s is scalar, since space has no direction in time. The term Λ is then a vector quantity representing the time displacement per unit of space, this being the time-oriented quantity corresponding to velocity in space-oriented phenomena.

From the foregoing, the reason for the scalar nature of the space-time progression, which is motion in both space and time, is evident. Since time has no direction in space and is therefore a scalar quantity so far as motion in space is concerned, and for similar reasons, space is a scalar quantity so far as motion in time is concerned, it follows that motion in *both* space and time cannot have a direction in *either* space or time. Hence motion in space-time is scalar.

We may summarize the conclusions with respect to the directional characteristics of the various kinds of motion as follows:

> In the equations of motion in space, time is scalar.
>
> In the equations of motion in time, space is scalar.
>
> In the equations of motion in space-time, both space and time are scalar.

Some readers of the previous volumes of this series have found it difficult to accept the idea that time can be three-dimensional because this makes any time interval a vector quantity and presumably leads to situations in which we are called upon to divide one vector quantity by another. As indicated in the foregoing discussion, however, such situations are non-existent. If we are dealing with spatial relations, time is scalar because time has no direction in space. If we are dealing with temporal relations, space is scalar because space has no direction in time. *Either* space or time can be vectorial, but there is no physical situation in which *both* are vectorial.

Since the property which we are calling "direction in time" is something quite distinct from "direction" as we ordinarily use the term in the sense of "direction in space," there might be some good arguments in favor of coining a new name and not using the word "direction" for this purpose. This would do doubt contribute toward clarifying such issues as the reason why time is always scalar in the equations of space

motion irrespective of the number of dimensions which time itself may have. On the other hand, it should not be difficult to get away from the habit of interpreting "direction" as meaning "direction in space." As a matter of fact, we already recognize that the spatial connotation that we give to the word "direction" is in many cases fictitious. A scalar quantity is specifically defined as one, which has no direction, yet we habitually use the word "direction" and directional terms of one kind or another in speaking of scalar quantities, or even in connection with items, which cannot be expressed in physical terms at all. We speak of wages and prices as moving in the same direction, temperature as going up or down, a change in the direction of our thinking, and so on. Here we recognize, consciously or unconsciously, that in our definition of a scalar quantity we are using the term "direction" in the sense of "direction in space," whereas when we are talking about the direction of price change or something similar we are using the word "direction" without any spatial significance. It should not require any great mental effort to apply the same viewpoint to temporal quantities and to recognize that here also the term "direction" has no spatial significance.

On the other side of the ledger, there are some very definite advantages to be gained by utilizing the term "direction" in reference to time as well as in reference to space. Because of the symmetry of space and time, the property of time that corresponds to the familiar property of space that we call "direction" has exactly the same characteristics as the latter, and by using the term "direction in time" as a name for this property we convey an immediate understanding of its nature and characteristics that would otherwise take a great deal of discussion and explanation. All that is then necessary is to keep in mind that although direction in time is *like* direction in space, it is *not* direction in space.

This is a general situation that applies all through the space-time relations. The impact of time on our consciousness is vague and elusive, and it is therefore quite difficult to visualize any concrete physical situations involving three-dimensional time. The most effective way of grasping the essentials of the participation of time in such situations is to visualize the corresponding space phenomenon and then recognize that the time phenomenon is exactly the same except that space and time are reversed. In order to do this easily and efficiently it is necessary to utilize the same terms for the corresponding space and time entities, and this policy has been followed throughout the present series of publications.

As brought out in Chapter V, the developments of this work, revolutionary as they may be in some of their aspects, have very little effect on the physical processes and relations of everyday life. The reason is now apparent. In our everyday experience we are dealing with *motion in space,* and the laws and principles governing motion in space are already firmly established. Any correct theoretical development must necessarily lead to these same laws and principles. The discovery of the possibility of motion in time and the formulation of the analogous laws and principles governing this type of motion has no effect on any situation where all motion is in space.

But physical science is now penetrating into regions where motion in time plays an important, often controlling, part in physical phenomena, and much of the difficulty that the present-day physicist is encountering in his attempts to systematize knowledge in these regions is due to his attempt to treat the phenomena in these regions by means of the relations applicable to motion in space, while the motion with which he is dealing is actually, in whole or in part, motion in time.

The problem, which Einstein faced in setting up his Special Theory of Relativity, is typical. In the light of the information that has been developed in this work we may compare it to the problem that would confront anyone who knew nothing of the concept of direction and who attempted to devise a scalar equation to relate speed and velocity. The latter would, of course, be nothing but another scalar quantity to anyone who is unaware of the existence of direction, just as the time entering into a high velocity was to Einstein no different from the time entering into a low velocity, aside from the difference in magnitude. Such an investigator would find it entirely possible to devise an accurate mathematical relation that would apply to some *special* speed-velocity situation, in the same way that the Lorentz equations apply to uniform translational motion, but it is obvious that there can be no *general* relation of a scalar character connecting speed and velocity. If a "Special Theory" of the speed-velocity relation is devised for some special case, sinusoidal motion, let us say, and the success of the theory in this particular area leads its originators and supporters to believe that it can be extended to motion in general, the outcome will inevitably be either that the attempts are ultimately given up as hopeless, or that successive *ad hoc* modifications of the original theory finally result in a "General Theory" of the speed-velocity relation which is so vague and confused conceptually and so complex mathematically that no one can pin it down closely enough to reveal its true character.

A valid general solution of the hypothetical speed-velocity problem cannot be obtained until someone discovers the three-dimensionality of space and introduces the concept of direction. Similarly no general solution for Einstein's problem was possible until this present investigation discovered the three-dimensionality of time and introduced the concept of motion in time. But in both cases the answer is simple and obvious as soon as the necessary conceptual foundation has been laid.

Hesse sums up the position in which physics stands *without* the concept of motion in time as follows:

> The fundamental logical proposition to which all such theories must conform is that one cannot assert *both* that the velocity of light is invariant for all possible reference frames, *and* that the geometry of light rays is Euclidean.[54]

The general and uncritical acceptance of this so-called "logical proposition" is the factor that has forced physical theory into the uncomfortable and untenable position that it occupies today. The truth is that this is not logical at all. It could be logical only if coupled with a proviso that the existing concepts of the nature of space, time, and motion must be maintained unchanged, and there is clearly no *physical* justification for such a proviso. There has never been any assurance that these concepts are physically valid; on the contrary, they are pure assumptions, and the development of the Reciprocal System has now demonstrated that they are *erroneous* assumptions. If they are replaced by concepts that *are* physically valid, then it is possible to formulate a logical and self-consistent alternative to the Special Theory which does just exactly what Hesse claims is impossible; that is, it reconciles Euclidean geometry with the constant velocity of light.

A brief summary of the detailed explanations of this situation that have been published elsewhere can be given with the aid of the diagram, Figure 1. Let us assume that a ray of light from a distant source S passes

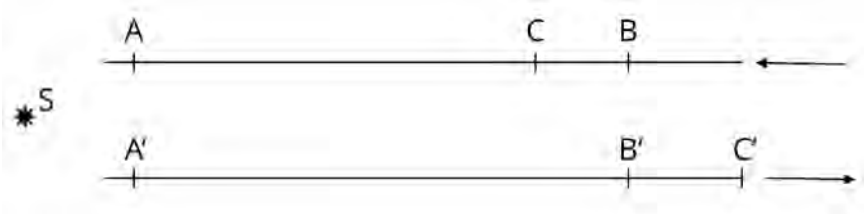


Figure 1

from A to B and from A' to B' in two parallel systems. Then let us assume that the systems AB and APB' are in motion in opposite directions as shown, and are in coincidence as the light ray passes A and A'. Because of the motions of the respective systems, point B will have moved to some point C closer to A by the time the light reaches it, whereas B' will have moved to some more distant point C'. Yet if the results of the Michelson-Morley experiment are to be believed, the velocity of the incoming ray at C is identical with the velocity of the incoming ray at C'; that is, the velocity of light is independent of the reference system.

The *interpretation* that has been placed on the results of this experiment by the physicists is that the time required for the light ray to pass from A to C is the same as the time required to pass from A' to C'. From a common sense viewpoint this conclusion is absurd, and the feeling of discomfort which most laymen, and many scientists, experience on contact with Relativity theory is basically due to the fact that Einstein made this contradiction of common sense the cornerstone of his theory. With the benefit of the discussion earlier in this chapter, it is now evident that the physicists' interpretation of the Michelson-Morley experiment is wrong, and that the conflict with common sense was wholly unnecessary. The time AC is *not* the same as the time A'C'. It is only the *clock time* that is the same in both systems, and the clock time is only *one component* of the total time.

In our observations of the distant galaxies we can ignore the random motion of these objects–the motion in coordinate space—because it is so small that its effect is negligible compared to the effect of the motion of the recession—the motion in clock space. But if this random motion were taking place at a velocity in the neighborhood of that of light, the situation would be quite different. This motion in coordinate space would then have a very appreciable effect on the total displacement of the galaxy during any interval of observation and we could no longer ignore it.

Similarly, the change in temporal location—the displacement in coordinate time—at the relatively low velocities of our ordinary experience is negligible in comparison with the time of the progression—the clock time—and we can disregard it. But here again, this ceases to be true at the velocity of light. At high velocities the coordinate time has a finite magnitude, and the total time, the time that actually enters into physical relations, is the vector sum of the clock time and the coordinate time. The total time required for the light ray to pass from A to C in the

moving system is the clock time ab minus the coordinate time cb, or ac, and the velocity is the space displacement AC divided by the net total time act The total time for the ray to pass from A' to C' is the sum of the clock time a'b' and the coordinate time b'c', or a'c', and the velocity is the space displacement A'C' divided by the total time a'c'. The velocity of light is thus AB/ab for a system at rest, AC/ac in the system moving toward the light source, and A'C'/a'c' in the system moving away from the light source.

Inasmuch as one unit of time is equivalent to one unit of space, according to the postulates of the Reciprocal System, this means that the velocity of light is unity — one unit of space per unit of time — in all three cases. And the theory further tells us that this velocity cannot be other than unity under any circumstances, because a light photon has no motion of its own. The photon stays permanently in the same space-time unit in which it originates and is carried along by the progression of space-time itself. The progression moves one unit of space per unit of time simply because one unit of space is one unit of time and the equivalence of unit space and unit time is the progression. Even in passing through matter, where the *measured* light velocity is less than unity, the *true* velocity still remains one unit of space per unit of time. The factors, which cause the measured velocities to diverge from unity under these conditions, will be considered in a subsequent chapter.

As can be seen from the foregoing explanation, the concept of motion in time, which is one of the necessary consequences of the postulates that were derived by extrapolating the observed properties of space and time, solves Einstein's problem, the problem posed by the results of the Michelson-Morley experiment, in an easy and natural way without any distortion of established physical principles. Notwithstanding Hesse's statement that the constant velocity of light is logically incompatible with Euclidean geometry, this solution of the problem, number six in our list of Outstanding Achievements; is completely in harmony with both. In spite of the general belief that the Michelson-Morley results cannot be explained without giving up the idea of absolute space and time, Einstein's positive assertion, on the same grounds, that "moving rods must change their length, moving clocks must change their rhythm,"[88] and all of the chorus of similar statements throughout scientific literature, the findings of the Reciprocal System are entirely consistent with both the constant velocity of light and the existence of absolute magnitudes of space and time.

Here again, as in so many other situations that have been discussed in the several volumes of this series, previous investigators have simply failed to examine possible alternatives. It is true that in this case the correct alternative was more effectively hidden below many layers of long-standing habits of thought than in most other instances, and overlooking it was more a matter of inadvertence than a deliberate ignoring of unpopular alternatives, as in some other instances, but failure to be on the alert for alternatives is a serious defect in scientific practice. The consequences of error are always the same. Nature rewards only the correct answers; it gives no credit for effort, nor does it make allowances for extenuating circumstances. The plain truth is that the physicists should have recognized the *possibility* of a more satisfactory alternative to the Special Theory, irrespective of whether or not they were able to formulate anything acceptable, and a substantial part of the immense amount of effort that has been wasted in a futile attempt to patch up the weak spots in that theory should have been applied to searching for such an alternative. Failure to *find* the correct answer is, of course, excusable — even the most diligent efforts by the most competent individuals do not always reach their goals — but failure to *look for* the correct answer, because of unwillingness to admit that currently accepted ideas *could* be wrong, is a fair target for criticism.

The revolutionary change in outlook that accompanies the application of the concept of motion in time to the Relativity problem is typical of the way in which this concept clears up confusion and contradictions in all of the far-out regions: the realm of the very small (atomic physics and quantum theory), the realm of the very fast (gravitation and Relativity Theory), and the realm of the very large (astronomy and cosmology). All through these areas hitherto complex and difficult problems are reduced to simple and understandable terms when they are viewed in the context of the new conceptual structure.

Phenomena at the atomic level have been particularly baffling to the physicist. From the very first, those who sought to formulate theories and mathematical formulae to represent atomic processes have found it necessary to abandon established physical principles and to base their theoretical developments on *ad hoc* assumptions and specially devised principles of impotence. In spite of the unparalleled freedom of thought thus attained (or perhaps, more accurately, *because* of it) the theories which the physicists have developed have encountered serious difficulties at every turn, and have never been adequate to

meet the constantly growing demands upon them. The experimental branch of physics is continually discovering new phenomena and new characteristics of previously known phenomena, which the theoretical branch did not anticipate and cannot reconcile with their existing theories. Each experimental advance thus requires a wholesale modification of these theories and a new batch of ad hoc assumptions.

The difficulties in which current atomic theory is now enmeshed were discussed in detail in *The Case Against the Nuclear Atom,* but that work was purely a critique of existing thought in the atomic field and it did not offer any new explanations of the matters at issue. The preceding discussion has now laid the foundation for a new theoretical understanding of motion in the atomic region.

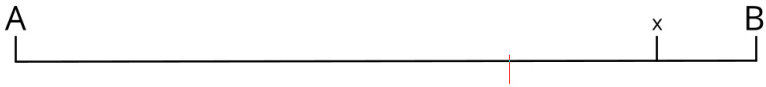


Figure 2

Let us consider an atom A in motion toward another atom B through free space (Figure 2). According to accepted ideas, atom A will continue to move in the direction AB until the atoms, or the force fields surrounding them, if such fields exist, are in contact. The postulates of the Reciprocal System specify, however, that space exists only in units, hence when atom A reaches point x, one unit of space distant from B. it cannot move any closer to B *in space.* It is, however, free to change its position *in time* relative to the time location occupied by atom B. The reciprocal relation between space and time makes an increase in time separation equivalent to a decrease in space separation, and while atom A cannot move any closer to atom B in space, it can move to the *equivalent* of a spatial position that is closer to B by moving outward in coordinate time. When the time separation between the two atoms has increased to n units, space remaining unchanged, the equivalent space separation, the quantity that will be determined by the usual methods of measurement, is then $\frac{1}{n}$ units. In this way the measured distance, area, or volume may be a fraction of a natural unit, even though the actual one, two, or three-dimensional space cannot be less than one unit in any case.

So far as the inter-atomic distance itself is concerned, it is not very material whether this is an actual spatial separation or merely the equivalent of such a separation, but the fact that the movement of the atoms changes from a motion in space to a motion in time at the

unit level has some important consequences from other standpoints. For instance, the spatial direction AB in which atom A was originally moving no longer has any significance inside unit distance, as the motion in time which replaces the previous motion in space has no spatial direction. It does have what we choose to call a direction in time, but this temporal direction has no relation at all to the spatial direction of the previous motion. No matter what the spatial direction of the motion of the atom may have been before unit distance was reached, the temporal direction of the motion *after* it makes the transition to motion in time is determined purely by chance.

Any kind of action originating in the region where all motion is in time is also subject to significant modifications if it reaches the unit boundary and enters the region of space motion. For example, the connection between space motion and time motion is scalar" and consequently only one dimension of a two-dimensional or three-dimensional motion can be transmitted across the boundary. This point will have an important bearing on one of the phenomena that will be discussed later.

Another important fact is that the effective direction of the space-time progression reverses at the unit level. Outside unit space the progression carries all objects outward in space away from each other. Inside unit space only time progresses and since an increase in time, with space remaining constant, is equivalent to a decrease in space, time progression in this region, the *time region,* as we will call it, moves all objects to locations which, in effect, are closer together. The gravitational motion always opposes the progression and hence the direction of this motion also reverses at the unit boundary. As it is ordinarily observed in the time-space region, the region outside unit distance, gravitation is an inward motion, moving objects closer together. In the time region it acts in the outward direction, moving objects farther apart.

On first consideration it may seem illogical for the same force to act in opposite directions in different regions, but from the natural viewpoint these are *not* different directions. As brought out in Chapter VI, the natural datum is unity, not zero, and the progression therefore always acts in the same *natural* direction: away from unity In the time-space region away from unity is also away from zero, but in the time region away from unity is toward zero. Gravitation likewise has the same natural direction in both regions, in this case toward unity.

It is this reversal of direction at the unit level, which enables the atoms to take up equilibrium positions and form solid and liquid aggregates. No such equilibrium can be established where the spacetime progression is outward, because in this case the effect of any change in the distance between the atoms resulting from an unbalance of forces is to accentuate that unbalance. If the inward-directed gravitational force exceeds the outward-directed progression, an inward motion takes place, making the gravitational force still stronger. Conversely, if the gravitational force is the smaller, the resulting motion is outward, which further weakens the already inadequate gravitational force. Under these conditions there can be no equilibrium.

In the time region, however, the effect of a change in relative position opposes the unbalanced force, which caused the change. If the gravitational force (outward in this region) is the greater, an outward motion takes place, weakening this gravitational force and ultimately reducing it to equality with the constant inward-directed force of the progression. Similarly, if the force of the progression is the greater, the movement is inward, and this increases the gravitational force until equilibrium is reached.

This is a most important finding: one that is unquestionably entitled to be designated as Outstanding Achievement Number Seven. The equilibrium that must necessarily be established between the atoms of matter inside unit distance in the RS universe obviously corresponds to the observed inter-atomic equilibrium that prevails in solids and, with certain modifications, in liquids. Here, then, is the explanation of solid and liquid cohesion that we derive from the Reciprocal System: the first comprehensive and completely self-consistent theory of this phenomenon that has ever been formulated. The mere fact that it is far superior in all respects to the currently accepted electrical theory of matter is not, in itself, very significant, inasmuch as the electrical hypothesis is definitely one of the less successful segments of present-day physical theory, but a comparison of the two theories should nevertheless be of interest from the standpoint of demonstrating how great an advance the new theoretical system actually accomplishes in this particular field.

The first item to be noted is that we are not replacing the electrical theory of matter with another "theory of matter." The Reciprocal System is a complete general theory of the universe; it contains no hypotheses other than those relating to the nature of space and time and it produces an explanation of solid cohesion in the same way that it derives logical

and comprehensive explanations of other physical phenomena, simply by development of the consequences of the space-time postulates. We therefore do not have to call upon any additional force of a hypothetical nature to account for the cohesion; the same thing that makes the atom an atom — the rotation in three dimensions — accounts for both the inward force of gravitation in the region outside unit distance and the existence of the inter-atomic equilibrium inside this distance.

Another significant point is that the new theory identifies *both* of the forces that enter into the inter-atomic equilibrium. One of the major defects of the electrical theory is that it only provides one force, the hypothetical electrical force of attraction, whereas two opposed forces are required to explain the observed situation. Originally it was assumed that the atoms were impenetrable and that the electrical forces simply held them in contact, but present-day experimental knowledge of compressibility and other properties of solids has demolished this hypothesis and it is now evident that there must be what Karl Darrow calls an "antagonist" to counter the attractive force, whatever it may be, and produce an equilibrium. Physicists have been unable to find any such force and, as Darrow says, they take refuge in evasion, and "manage to avoid the question, by using "words not conveying directly the notion of force."[89]

A particularly important advantage of the Reciprocal System is that it utilizes the *same* mechanism for the cohesion of *all* substances. The basic hypothesis of the electrical theory — that of a force of attraction between a hypothetical positively charged constituent of the molecule and a hypothetical negatively charged constituent — is applicable only to a restricted class of solid substances and it is necessary to call upon weird ideas such as "shared electrons" to replace the basic hypothesis where the latter is clearly inapplicable. Even with this extraordinary kind of latitude, the theory is still in serious trouble. It is freely admitted, for instance, that there is still no plausible explanation for the cohesion of metallic aggregates. The superiority of an all-inclusive theory is obvious.

The *directional* characteristics of the inter-atomic forces are also explained in an easy and natural way by the Reciprocal System, whereas the electrical theory has practically nothing to contribute in this respect. Inasmuch as the atomic forces, according to the new system, result from rotation in three dimensions, and each dimension has its own specific rotational velocity, it is evident that a change in the inter-atomic orientation will alter the force, which the atom exerts on its neighbor.

Although the foregoing items add up to a very impressive total, the greatest triumph of the new system in this particular area is mathematical. By means of methods outlined in Chapter XV it is possible to determine the magnitudes of the rotational motions in each of the three dimensions of the atoms of the different chemical elements and the magnitudes of the corresponding directional forces. Equating these forces to the constant force of the space-time progression and solving for the equilibrium distance then gives us the inter-atomic distance or distances for each element or compound. As shown in *The Structure of the Physical Universe,* where these calculations are carried out in detail, there are uncertainties in the structures of the more complex substances that cause the result to take the form of a set of possible values in each instance rather than a specific figure, but for the simpler substances the calculated distance is definite and unequivocal, and in all of these cases it agrees with the experimental results within the margin of uncertainty of the latter. Additional studies, as yet unpublished, show that this agreement between the theoretical and experimental values holds good not only at normal pressures but also throughout the entire experimental pressure range, up to 100,000 atm. static pressure and to several million atmospheres by the recently developed shock wave techniques.

These results, the quantitative as well as the qualitative, are derived solely from the postulates concerning the nature of space and time, without any additional assumptions or any reference to the data of observation. Development of the consequences of the postulates reveals that there must exist certain combinations of rotational and vibrational motion, that the possible combinations of this type form a series in which each successive member possesses one more net unit of motion than its immediate predecessor, that, for example, a unit of number 19 in this series will form an equilibrium structure with other units of the same kind, in which each individual is separated from its immediate neighbors by the equivalent of 1.541 natural units of distance, and that number 19 will also combine with number 35 in the series, and the resulting 19-35 combination will form an equilibrium structure in which each individual is the equivalent of 1.133 natural units distant from its nearest neighbor.

All of the foregoing is purely theoretical and entirely independent of anything that may exist in the actual physical universe. It is simply a description of conditions and mathematical relations, which

are necessary consequences of the Fundamental Postulates of the Reciprocal System and which therefore, must exist in the theoretical RS universe. But having come this far, we can now compare these features of the RS universe with the corresponding features of the observed physical universe. When we do this we find an exact agreement all the way down the line. The units of compound motion are atoms of matter, the series of these combinations is the series of chemical elements, numbers 19 and 35 in this series are the elements potassium and bromine respectively, their combination is potassium bromide, and the equilibrium structures which are formed are solid aggregates of these substances. By making some one measurement, either of an actual inter-atomic distance or of an appropriate combination of basic physical constants, we can identify the ratio of conventional units (Angstrom units) to natural units of distance as 2.914. Applying this ratio to the inter-atomic distances calculated theoretically, we obtain 4.49 for potassium and 3.30 for potassium bromide. Representative values from experiment are 3.29 for potassium bromide and 4.50 to 4.54 for potassium.

This, then, is another demonstration that the theoretical RS universe derived from the postulates of the Reciprocal System is identical with the observed physical universe: a demonstration which is particularly significant in that it involves a long chain of theoretical deductions, which are in complete agreement with the observed facts at every step of the way, and which ultimately lead to specific numerical values which can be compared directly with the corresponding experimental results.

CHAPTER IX

The States of Matter

Under the conditions prevailing in our local environment, a static equilibrium of the kind described in the preceding chapter never exists other than momentarily, as the individual atoms are able to acquire translational motions of their own, independent of both the space-time progression and the opposing scalar effect of the atomic rotation. This translational or thermal motion is readily transferred from atom to atom by any one of several processes and hence any motion of this kind that may exist in a particular region is promptly distributed among all of the atoms present. The study of the behavior of matter—of its properties—therefore deals with atoms in motion rather than static atoms, and these properties depend upon the magnitude of that motion as much as they do upon the characteristics of the atoms themselves, often more so.

As mentioned previously, the original development of the theoretical structure which is being presented in this work did not take the short and easy route that was followed by the hypothetical race of supermen in Chapter IV, but was the result of a long and difficult process of fitting together bits of information gathered by study and analysis of many separate physical phenomena. Because of the large amount of detailed and reasonably accurate quantitative information that is available regarding the physical properties of matter, the investigation of these properties has been one of the principal areas of concentration and the theoretical development has been extended into great detail throughout this field.

In each of the areas covered, including the thermal expansion, specific heat, compressibility, resistivity, crystal structure and melting point of solids, the volume, specific heat, compressibility, surface tension, viscosity, refractive index, magnetic susceptibility and boiling point of liquids, and the PVT relations, critical constants and viscosity of gases, the general principles governing the property inquisition have been worked out by a further development of the consequences of the

postulates of the Reciprocal System, and the validity of the conclusions thus reached has been verified by calculating the theoretical values for many different substances under many different conditions and comparing these with the results of experiment. Because of the tremendous scope of this field and the finite amount of time that has been available for the task, the cover age of the different items has not been uniform. In some instances it is reasonably complete. The solid compressibility calculations, for instance, have reproduced practically all of the experimental values available in the range above 1000 atm. where the compressibility is great enough to be significant. Another property that has been given a very comprehensive treatment is liquid volume. The theoretical volumes for nearly a thousand liquids have been calculated, many over extensive ranges of temperature and pressure. Since the agreement between the theoretical and experimental values is within the margin of uncertainty of the experimental results in both the liquid volume and the compressibility comparisons, the validity of the theoretical relations in these areas is definitely established. In some other areas, particularly where the experimental data are meager and unreliable, the "fine structure" of the theory is less certain, but even in these cases there is every reason to believe that the general relations deduced from the theoretical foundations are correct.

Obviously a presentation of the immense amount of numerical data accumulated in support of the conclusions reached in these studies is far outside the limits that have been established for this present volume, and publication of these quantitative results will therefore have to be deferred to subsequent volumes in the series. The qualitative agreement between these conclusions and the results of observation is, however, very striking in itself, and the orderly and systematic way in which hitherto recalcitrant phenomena fall into line in this new development is quite impressive. A brief survey of some of the principal findings in this field, particularly the new information that has been developed as to the nature and origin of the different states of matter, should be quite appropriate in the present context.

The thermal motion, like the scalar effect of the rotation, necessarily opposes the space-time progression, for the same reason, and the addition of motion of this type therefore displaces the equilibrium in the outward direction. The first effect of the motion is thus an expansion of the solid structure. This direct and positive result

is particularly interesting in view of the fact that previous theories have always been rather vague as to why such an expansion occurs. These theories visualize the thermal motion of solids as an oscillation around equilibrium positions, but they fail to shed much light on the question as to why the equilibrium positions should be displaced. A typical "explanation" taken from a physics text says, "Since the average amplitude of vibration of the molecules increases with temperature, it seems reasonable that the average distance between the atoms should increase with temperature."[90] But it is not at all obvious why this should be "reasonable." As a general proposition, an Increase in the amplitude of a vibration does not, of itself, change the position of equilibrium. Some explanation other than increased amplitude must be found to account for the expansion. In the RS universe the connection between the thermal motion and the expansion is explicit. Any such motion, however small, adds to the outward-directed forces and hence displaces the inter-atomic equilibrium outward.

Pressure displaces the equilibrium in the opposite direction and thus reduces the inter-atomic distance and the corresponding atomic volume. Here, as in so many other physical phenomena examined during the course of this project, the actual mechanism turns out to be much simpler than has ever been suspected heretofore. The development of theory indicates that the solid volume under compression is not properly represented by the kind of a complex function that has usually been employed by those who have attacked this problem–a function generally involving some fanciful concept such as that of an inverse sixth power force–but follows a very simple relation analogous to Boyle's Law, except that in the solid the volume is inversely proportional to $P^{½}$ rather than to P; that is, for the solid structure $PV^2 = k$. Unlike the gaseous aggregate that conforms to Boyle's Law, however, the solid is subject to the equivalent of a pressure even when no external pressure is applied, as the excess inward force that causes the equilibrium to be established somewhere *inside* unit distance has the same kind of an effect as the external pressure. The solid is thus partially compressed before the external pressure is applied, and the total pressure represented by the symbol P in the expression $PV^2 = k$ is the sum of the initial pressure and the external pressure. If we use the symbol P to refer to the external pressure only, in accordance with the usual practice, the compressibility equation becomes $(P_0 + P)V^2 = k$.

It is the effect of this initial pressure that is responsible both for the wide differences in compressibility between different substances and for the seemingly complex nature of the mathematical relation between solid volume and pressure. The compressibility curves for very compressible substances and relatively incompressible substances are not altogether different curves, as they appear to be; they are merely different segments of the same curve. The observed sodium curve, for example, is nearly complete and has the characteristic exponential shape, whereas the observed platinum curve is practically linear, but this difference is simply due to the variation in the magnitude of the section of the theoretical curve that is cut off by the initial pressure. Calculations indicate that the initial pressure for sodium is only 18,000 atm., and the pre-compression of solid sodium is therefore relatively small, whereas the platinum initial pressure has the extremely high value of 1,295,000 atm., which means that this metal is already highly compressed before any external pressure is applied.

This concept of pre-compression by the forces responsible for solid cohesion, one of the necessary consequences of the postulates of the Reciprocal System, is typical of the new ideas through which the system is able to accomplish a drastic simplification of the entire solid and liquid picture. There is nothing remarkable about the idea itself; it is the kind of thing that seems practically self-evident after it is once pointed out. But it enables treating the resistance to compression as a simple force subject to accurate evaluation independently of the compression process, rather than having to postulate some purely *ad hoc* and mathematically complicated force for the purpose. Of course, the compression pattern for the solid does not have the extreme simplicity of the relations obeyed by the compression of diffuse gases, but this cannot be expected in view of the more complex nature of the solid structure. Most of the changes to which the solid structure is subject, including not only the discontinuous first order transitions but also the more subtle second order transitions, alter the effective initial pressure and thus modify the compression curve. However, this modification does not replace the simple curve by a complex and mathematically difficult relation; it merely means that instead of one simple curve amenable to easy and accurate mathematical treatment we now have a series of simple curves equally amenable to the same kind of treatment.

If the magnitude of the thermal motion is progressively increased, a point is ultimately reached at which the sum of the outward-directed

motions, the thermal motion and the scalar effect of the atomic rotation, exceeds the sum of the inward-directed motions, the space-time progression and the equivalent of the external pressure. The inter-atomic force of cohesion then vanishes in one dimension. The atom is still restricted to vibratory motion within one unit of space of its nearest neighbors in two dimensions, but it is now free to move in space in the third dimension. The result of this one-dimensional freedom that is acquired when the atom reaches what we will identify as the *melting point* is a continuing realignment of the inter-atomic forces, as a consequence of which the atoms (or molecules) move about at random through the aggregate and no longer have any permanent neighbors.

Even though this freedom of motion acquired by an atom or molecule which reaches the one-dimensional limit is a rather restricted sort of liberty, it is enough to cause a very substantial modification of the physical properties of the unit: a change of sufficient magnitude to justify looking upon this new condition as a different state of matter. In this liquid state the aggregate still has a definite volume, just as it did in the solid state, since the constituent molecules maintain a fixed average inter-molecular distance, but it no longer has a specific form, as the freedom in one dimension allows the molecules to change their relative positions under the influence of external forces and the liquid aggregate therefore conforms to the requirements imposed by these external forces. In general this means that it assumes the shape of its container.

As is evident from the foregoing, the development of the Reciprocal System introduces a totally new concept of the nature of the liquid state. In current thought this state is v dewed as a property of the *aggregate*; it is a "state of aggregation." As ordinarily explained, the atoms or molecules are able to maintain the fixed average positions of the solid structure until the thermal energy reaches a certain magnitude, but beyond this point the inter-atomic forces of attraction are unable to return them to the equilibrium positions and the orderly arrangement of the crystal gives way to the random arrangement of the liquid. Development of the consequences of the postulates of the new system now indicates that this viewpoint is wrong; that the liquid state is basically a property of the individual atom or molecule, and the state of the aggregate is simply a reflection of the state of the majority of its constituent molecules.

There are many items of evidence, which demonstrate the validity of the new concept. One direct confirmation can be obtained from an examination of some of the properties of solutions. It has long been recognized that these properties are quite sensitive to the melting point of the solute; that is, the properties of a liquid-liquid solution often differ materially from those of the corresponding solid-liquid solution. Some of the less soluble substances, particularly, show a very marked change at the melting point, separating into the two-layer structure characteristic of many of the liquid-liquid solutions. In preparing a liquid-liquid solution of this kind it makes no difference whether we put the solid into the liquid and then raise the temperature of the solution beyond the melting point, or whether we liquefy the solid independently and add the solute to the solvent. In each process there is a very decided change in properties at a specific temperature, and in both cases this is the same temperature: the solute melting point. The logical conclusion is that the process in the solution is the same as that outside the solution; in other words, that the solute is in the solid state below its melting point regardless of its environment and it makes the transition to the liquid state at its normal melting temperature in solution as well as out of solution.

The significance of these points in relation to the present subject lies in the fact that the solute is known to exist in units of molecular or ionic size in the solution. If the solute is in the solid state below its melting temperature and in the liquid state above this temperature, this means that it exists in the form of *solid molecules* (or ions, which will be included in the term "molecule" for purposes of this present discussion) and *liquid molecules* respectively. Obviously the existence of distinct solid and liquid molecules under *any* conditions precludes the possibility that the liquid and solid states are "states of aggregation" and establishes the fact that physical state is essentially a property of the individual molecule, as required by the principles developed in this work.

The most conclusive verification of the validity of the new concept comes, however, from the accurate calculation of the numerical values of the properties of both the solid and the liquid aggregates in the vicinity of the melting point that is made possible by its application. Because of the distribution of molecular velocities due to probability effects, the thermal energy of the individual molecules of an aggregate

varies over a substantial range, and hence a liquid aggregate at any temperature in the neighborhood of the melting point contains a specific proportion of molecules whose temperature is below the melting point and which, as a consequence, are individually in the solid state and have the properties–volume, specific heat, etc.–appertaining to that state. Similarly a solid aggregate at a temperature in the neighborhood of the melting point contains a specific proportion of molecules whose temperature is above the melting point and which, accordingly, are individually in the liquid state. It has been found in this investigation that most of the temperature-dependent properties of solids and liquids are either inherently linear with respect to temperature or can be mathematically stated in such a manner that they can be graphically expressed in linear form. When these linear curves approach the melting point they invariably bend toward the values appropriate to the alternate state.

This is, in itself, a significant qualitative confirmation of the new theory, but mathematical analyses of the patterns of these deviations from the linear relation have supplied a large amount of quantitative data to support the qualitative conclusions. In the course of the present study the observed values of the physical properties of hundreds of solid and liquid substances in the vicinity of their melting points have been reproduced by applying the percentage of "foreign" molecules determined from the probability principles to the appropriate magnitudes of the properties of the pure solid and pure liquid. The correlation between the theoretical and experimental values is particularly striking in the case of such properties as liquid volume and solid specific heat where the experimental results have a high degree of accuracy.

A set of values that is of special interest is obtained where the property in question is theoretically applicable to only one of the two states. For instance, the property of fluidity is incompatible with the basic nature of a solid. Some true solids will flow or "creep," under external pressure, but the distinctive feature of the solid state is a thermal energy less than that required to overcome the inward-directed forces, and the relative positions of the molecules of a true solid therefore cannot change under the influence of thermal forces alone; that is, a true solid cannot have any fluidity. It follows that the observed fluidity of certain solid aggregates is actually the fluidity of the liquid molecules in the solid aggregate, and the magnitude of this property is a direct

reflection of the proportion of such liquid molecules in the aggregate. The validity of this conclusion has been corroborated by calculations of the type described in the preceding paragraph.

The situation with respect to the vapor pressure of solid aggregates is similar. It is evident that a true solid, as herein defined, cannot have a vapor pressure. If a molecule does not have enough thermal energy to attain the restricted freedom of movement characteristic of the liquid state, it obviously cannot have the still larger amount of energy necessary to become a vapor. Here again it is clear that the observed property of the solid aggregate is not a property of the solid itself but of the liquid molecules within the solid aggregate. The vapor pressure of a solid at any specific temperature is therefore a function of the proportion of liquid molecules in the solid at that temperature.

Present-day textbooks tell us that "there is no sharp line of demarcation between solids and liquids,"[91] but aside from the glasses, which are a special class of substances whose unusual properties are due to certain peculiarities of their structure that we will not have space to discuss in this volume, the examples that are cited in support of this pronouncement are substances that contain significant percentages of both solid and liquid molecules throughout the temperature range in which they are commonly encountered. The difficulty in classifying these substances as solids or liquids results from the fact that they are not homogeneous; they are neither solids nor liquids, but are intermediate between the two states.

There is a "sharp line of demarcation" between true solids and true liquids; that is, between solid molecules and aggregates of solid molecules on the one hand, and liquid molecules and aggregates of liquid molecules on the other. Consequently, the melting points of pure substances (other than the glasses) are sharply defined. In fact, the range of melting or freezing temperatures is commonly used as a criterion of purity. Timmermans, for example, considers that a freezing range greater than one-tenth of a degree indicates that the sample in question is impure.[92] This is rather difficult to reconcile with the currently accepted view of the nature of the melting process, but it is entirely in harmony with the concept of melting as a phenomenon of the individual molecule that takes place at a sharply defined energy level.

The new theory also makes it clear why a solid aggregate cannot exist above the melting point, although it is possible, under favorable

conditions, to carry the liquid down to temperatures considerably below the normal freezing point. The change of state of the individual molecule always takes place at the appropriate melting point (which, for the molecule, is also the freezing point) and there are no superheated solid molecules or sub-cooled liquid molecules. Superheated solid aggregates are also ruled out, as the melting of the aggregate requires nothing more than an excess of liquid over solid molecules, hence the solid aggregate automatically melts when the normal melting temperature is reached. Freezing, however, is a more complicated process, and presence of the required number of solid molecules in the aggregate is not sufficient in itself. The molecules must also make contact with each other and must maintain that contact against the disruptive thermal forces long enough to enable additional molecules to link up with the original combination so that a stable solid nucleus can be formed. Where conditions are not favorable for this process the liquid aggregate may be cooled well below the normal freezing point before it solidifies. If the freezing point is approached by way of increased pressure rather than decreased temperature, the formation of a stable solid nucleus is still more difficult as the pressure constitutes an additional disruptive force tending to break up any momentary association between solid molecules before it can be built up into a permanent solid structure.

Two characteristic properties of the liquid state are surface tension and fluidity (viscosity). The nature of these properties is clearly indicated by the theoretical development. At the melting point adjoining atoms in the liquid are held together by a cohesive force of the same kind as that which exists in the solid, but effective in only two dimensions. This cohesive force, the surface tension, decreases as the temperature rises, since the additional thermal energy gradually cuts down the excess inward forces in the two dimensions that retain the characteristics of the solid. Fluidity is the inverse quantity, a result of the mobility resulting from the freedom to move in the limited liquid manner. It increases as the temperature rises, and reaches a maximum at the upper end of the liquid temperature range. We may regard the surface tension as a measure of the extent to which the liquid still retains the character of a solid and the fluidity as a measure of the extent to which it has acquired the character of a gas.

Surface tension, as the name implies, is commonly pictured as a *surface* phenomenon. "The existence of this surface tension," says

Kimball, "suggests that the surface of a liquid may be regarded as a stretched membrane enclosing the bulk of the liquid."[93] But even those who use such an analogy realize that the same forces must be effective throughout the liquid, and this author goes on to say, "Surface tension must have its origin in the attractive forces between molecules which hold the liquid together." The new light obtained from the Reciprocal System shows clearly that this view is correct and that the surface phenomena are simply differential effects due to the presence of adjoining molecules inside the surface but not outside.

The upper limit of the liquid is the *critical temperature*. At this temperature the molecule has enough thermal energy to overcome the cohesive forces in all three dimensions, and it therefore breaks away from its neighbors and moves independently through space. The molecule is then in the *gaseous state*.

Since the probability principles necessitate a distribution of molecular velocities above and below the average which determines the temperature of the aggregate, there are individual molecules passing out of the liquid state at all temperatures, the number of those escaping being determined by the molecular velocity distribution corresponding to the existing average temperature of the aggregate.

This is essentially the same condition that prevails in the vicinity of the melting point, where a certain proportion of liquid atoms is present in the solid aggregate and a certain proportion of solid atoms in the liquid aggregate. In the solid-liquid situation, however, the paths of motion for the two states are intermingled and both the solid and liquid molecules are distributed uniformly throughout the aggregate. The presence of the minor component can be recognized only by its effect on the properties of the aggregate. But when the high-energy molecules in the liquid break their ties with their neighbors they spread out in all directions and diffuse into all available space. The result is a physical separation between the molecules in the two different states.

Escape of the vapor molecules from the liquid aggregate reduces the proportion of high energy molecules in that aggregate below the level required by the probability relations and the energy inter changes within the liquid therefore bring other molecules up to the critical temperature. These molecules then also make their escape.

The loss of high energy molecules reduces the average temperature of the remaining liquid, but under normal conditions there is an

inflow of heat from the surroundings to compensate for this energy loss, and if the energetic molecules are escaping into free space the process is repeated over and over again until no more liquid remains. This process we identify as *evaporation.*

If the evaporated molecules enter a region whose temperature is below the critical level, they lose energy and conform to the ambient temperature, but this does not necessarily mean that they revert to the liquid state. The energy increment corresponding to a given temperature difference is much smaller for the free motion of the gaseous type than for the liquid motion, and the evaporated molecule may still retain sufficient kinetic energy to continue the free gas-type motion even at the lower temperature. The definition of the gaseous state is usually set up in such a manner as to include these free-moving molecules that are below the critical temperature, but from a theoretical standpoint there is enough difference in properties between these molecules and those above the critical temperature to justify considering them as being in a distinct state of matter: *the vapor state.*

In the theoretical RS universe the solid state is the state which exists where the motion of the molecule is confined entirely within one unit of space. The gaseous state is the state, which exists where the molecule is completely free to move in the region outside unit space. The liquid and vapor states are those, which exist in the intermediate region where the molecule is partially, free to move and partially restricted. We may regard the liquid state as an extension of the solid state into this intermediate region and the vapor state as an extension of the gaseous state into the same region.

The coexistence of the liquid and vapor states shows that the relation between these two is quite different from that between any other pair of states. Within the energy range of the solid no other state can exist. Likewise, the gaseous state is the only one that can exist within its range. Whether or not a molecule is in either of these states is therefore purely a question of its net energy balance. But if the energy level of a molecule is between the upper limit of the solid state and the lower limit of the gaseous state, the question as to whether this molecule is in the liquid state or the vapor state is not determined by the energy level; it is a matter of probability. In a relatively low-energy environment a state or condition requiring less energy is ordinarily more probable than one requiring more energy, where either can exist, but in the

liquid-vapor situation the probability considerations which determine the distribution of molecular velocities interfere with the operation of this rule. As long as any significant portion of the velocity distribution curve of the liquid extends up to the critical temperature the molecular transitions from liquid to vapor continue to take place regardless of the fact that the liquid state requires less energy.

If the liquid-vapor system is confined to a limited space, the velocities of the individual vapor molecules are likewise distributed over a range of values. This range extends down to condensation temperatures and some of the vapor molecules therefore revert to the liquid state. Increased evaporation creates a pressure, which accelerates condensation of the vapor and retards evaporation of the liquid, and eventually an equilibrium point is reached. Here the evaporation of the most energetic liquid molecules is exactly balanced by the condensation of the least energetic vapor molecules, and the relative proportions of liquid and vapor remain constant.

An increase or decrease in temperature changes the probability factors and shifts the equilibrium point up or down. Application of external pressure similarly displaces the equilibrium in the direction of more liquid and less vapor. By using sufficient pressure this process can be carried to the point where substantially the entire vapor aggregate has been condensed into liquid. This property of condensing under pressure is a direct result of the fact that the vapor state exists only by virtue of probability considerations, and it is one of the major points of difference between the vapor and the gaseous states. The gas cannot be condensed by pressure as the aggregate is in the gaseous state by virtue of the average energy level of the constituent molecules, a property which, unlike the relative probability, is not altered by pressure.

The concept of physical state as a property of the individual molecule which we derive by development of the consequences of the postulates of the Reciprocal System is another idea that, in itself, is neither extraordinary nor remarkable. It involves a distinct change in the previously existing viewpoint, to be sure, but not what would ordinarily be considered a revolutionary change, particularly since the transition from the liquid to the gaseous state in the evaporation process quite obviously takes place on an individual molecule basis and the new concept can therefore be regarded merely as a generalization of an already recognized process rather than something entirely new.

Nevertheless, the practical consequences of this innovation are of major importance, as they open the door to a full qualitative and quantitative understanding of the properties of liquids: a field in which the best efforts of scientific investigators have hitherto been distinguished by a very conspicuous lack of success. As expressed by Pitzer, whose comments apply specifically to the volumetric situation but are equally apropos in application to liquid properties in general, "The quantitative representation of the volumetric behavior of fluids over both gas and liquid regions has proven to be an unusually difficult problem."[94] The practical value of bringing system and order to this hitherto confused field of liquid properties is ample justification for considering this phase of the theoretical development as Outstanding Achievement Number Eight.

From a qualitative point of view the results of this change in the concept of the nature of physical state are immediate and direct, but from the quantitative standpoint one of its most important effects is to clear the ground for another general principle of wide applicability. This principle, another of the many unexpected results obtained by deduction from the basic postulates of the Reciprocal System, is that the temperature and pressure dependent properties of the fluid states of matter–liquid, vapor, and gas–are linear with respect to both temperature and pressure.

As long as physical state is viewed as a "state of aggregation" recognition of the linear nature of these relations is precluded, since the observed curves for the properties in question come in a great variety of shapes. Some are approximately linear, but many others show no linear tendencies at all. In the new physical picture the deviations of the properties of an aggregate of any particular fluid state from the theoretical linear relation are due to the presence of certain specific proportions of molecules which are individually in other states. The observed non-linear curves then result from superimposing the probability curves expressing the proportion of "foreign" molecules upon the standard linear curves for the pure state. Disentangling the two kinds of mathematical relations is sometimes a rather long and involved operation, but it is a relatively straightforward process that is practically certain to produce the correct results if sufficient time and effort are applied, and it therefore has a very wide potential field of practical application.

A collateral aspect of the new viewpoint as to the nature of the liquid state is that it gives us a simple and logical explanation of solid-liquid solutions. If a water aggregate, for example, can contain a certain proportion of solid ice molecules, as asserted by the new system and confirmed by analysis of the numerical values of the properties of the aggregate, then the presence of solid molecules of a different composition is easily explained as a phenomenon of the same general nature.

Another interesting and important aspect of the new physical picture originates from the inequalities that usually exist between the different inter-atomic force systems within the solid or liquid aggregate. In a crystal of an isotropic element all inter-atomic forces are alike, and the thermal energy required to overcome the cohesive force is therefore the same for all force systems in the aggregate. A term commonly employed in this connection refers to the cohesive force as a "bond", between the molecules, and if we use this term in the context of the explanation of atomic cohesion outlined earlier in this chapter, we may say that the bonds between the atoms of this homogeneous and isotropic aggregate are all alike. The same is true of many compounds of isotropic elements where the only bond that exists in the structure is that between element A and element B. The great majority of material substances, however, are either anisotropic, so that they have stronger bonds in some directions than in others, or have more than two components, so that there are different inter-atomic combinations within the aggregate.

In the compound KCN, for instance, the C-N bond is much stronger than either the K-C or the K-N bond. When the melting point is reached and the weakest bond gives way in one dimension, the C-N force system retains the solid characteristics in all three dimensions and, so far as the liquid motion is concerned, the CN combination acts as a single unit. In this respect the conclusions of the Reciprocal System do not differ materially from those of previous theories, but the existence of solid-type force systems in the liquid and the existence, for similar reasons, of both solid and liquid-type force systems in the vapor and gaseous states is a new finding that has a significant bearing on some of the properties of these fluid states.

Still another contribution of the new system in this area is a clarification of the observed localization of the atomic force of repulsion: the reason why "the repulsive forces are quite suddenly encountered when the inter-molecular separation is decreased."[95] A "sudden encounter"

with a new force is very difficult to explain by means of a theory which interprets the phenomenon in question as being the result of a gradual approach to the point of origin of the force—a "decrease in the inter-molecular separation"—and much of the difficulty which previous theories have experienced in this area is due to the inherent incompatibility between the *nature* of the observed facts and the *type* of theory utilized for their explanation. What is needed in order to explain the sudden onset of the repulsive force is an equally sudden change in the inter-atomic force characteristics, and this is what the Reciprocal System now provides. Outside unit distance the force due to the rotational motion of the atoms manifests itself as gravitational attraction. At unit distance the force directions are suddenly reversed and the former force of attraction becomes a force of repulsion.

In closing this brief survey of the application of the new theoretical system to the physical states of matter it may be appropriate, in view of the incredulity with which this idea of a force reversal at unit distance is often greeted, to emphasize the point that this reversal, like all of the other new concepts that have been discussed in this chapter, is a *necessary and unavoidable consequence* of the Fundamental Postulates of the Reciprocal System. However strange such an idea may seem to those who encounter it for the first time, it is a *deduction*, not an *invention*; it is a necessary result of the properties of space and time that were extrapolated from experience in Chapter IV. Although the idea of a force reversal may seem incongruous when it is encountered in an unexpected place such as this, force reversals are not at all uncommon in the physical realm and, significantly, the theoretical effects of this reversal are completely in harmony with the observed facts. Furthermore, it will be shown in Chapter XIV that the Particular kind of a force reversal that takes place at unit distance is not even a unique phenomenon; there are two other locations in the universe where essentially the same kind of thing occurs.

CHAPTER X

Astronomical Applications

In the astronomical world an accurate new theoretical system of the kind developed in this work has a particularly broad field of usefulness. Astronomy has always been under a handicap, as compared with other physical sciences, in that it is almost entirely observational rather than experimental, and to further complicate matters, the observations give only what amounts to an instantaneous picture, the changes, if any, being too small in most instances to be measure able within the period of time available. Where observations extend over a wide range of distance it is true that they also extend over a wide range of time, because of the finite speed of electromagnetic radiation, but this gives us no time dimension for the individual objects and, in general, evolutionary processes cannot be observed; they must be inferred. Even where the evidence of an evolutionary sequence is fairly plain, the direction of the evolution is rarely indicated in any unequivocal manner, and the astronomer is usually forced to rely upon collateral information of one kind or another in making his interpretation of the observations.

The availability of an accurate new physical theory, developed and verified in other physical fields where the facts are more readily accessible, now gives astronomy a new source of information which is not subject to the limitations that are inherent in the procedure that the astronomer normally employs. All of the features of the RS universe are purely theoretical products obtained entirely from a development of the necessary consequences of the postulates of the Reciprocal System without introducing anything from the observed physical universe or from any other outside source. The previous pages have shown how the mere existence of space and time with properties as postulated necessarily leads to the existence of theoretical entities that are identical with photons of radiation, atoms of matter, sub-atomic particles, and so on. Further development of the consequences of the postulates similarly requires the existence of theoretical entities

that we can easily correlate with stars, star clusters, galaxies, and other features of the astronomical universe, and it provides us with a complete definition of the theoretical properties of these entities. In view of the general proof that the theoretical RS universe is identical with the actual physical universe, it then follows that these theoretical entities and phenomena deduced from the postulates are true representations of the corresponding features of the physical universe. Since the theoretical development is not dependent in any way on existing observational or experimental knowledge, this conclusion is valid not only with respect to those features that can be verified by comparison with data from observation but also with respect to the features that cannot be so verified.

This new development therefore provides a unique opportunity of examining the subject matter of astronomy from an outside viewpoint completely independent of any conclusions that have been reached from consideration of the results of astronomical observation. In a sense, this is equivalent to getting a picture of the astronomical universe by means of a new kind of instrument of exceptional power and versatility. Like the invention of the telescope, the development of this new and powerful instrument now gives the astronomer an opportunity to widen his horizons greatly: to get a clear view of phenomena that have hitherto been hazy and indistinct, and to extend his investigations into areas that were totally inaccessible to the instruments previously available.

The picture obtained from this new instrument differs in many respects from present-day ideas–very radically in some instances–but the existence of such differences is clearly inevitable in view of the limited amount of information available to the astronomers and the consequent highly tentative nature of much of the astronomical theory currently in vogue. As has been demonstrated in the preceding pages, the correct explanation of a physical situation often differs from current ideas to a surprising degree even where the current theories have been successful enough to win general acceptance. In astronomy, where comparatively few issues have actually been settled, and differences of opinion are rampant, it can hardly be expected that the correct explanation will leave much of the previous theoretical structure intact.

In accordance with the general plan of this volume, the discussion of the astronomical situation will be limited to showing the effect that

the new concepts of space and time have an astronomical thought in general, without going into any more detail than is actually necessary. It appears that this can best be done by considering two specific examples: (1) the globular clusters, which we will take as representative of the class of phenomena for which the previously available data are reasonably adequate but are erroneously interpreted because of incomplete and misleading collateral information, and (2) the white dwarf stars, which we will take as representative of the class of phenomena whose true status cannot be understood at all without making significant changes in basic concepts.

The globular clusters are by far the most numerous of the reasonably permanent stellar aggregates. Many galaxies, including our own, are accompanied by hundreds of these distinctive and conspicuous objects, and one galaxy, M87, is reported to have in the neighborhood of a thousand associated clusters. But fitting these clusters into the structure of accepted astronomical theory has been a very difficult undertaking, and as late as 1946 an author was able to say that "no one has given an account of how these clusters must have originated or why they are found distributed as they are."[96] Even today writers not infrequently repeat Jeans, characterization of these structures as "mysterious objects." Present opinion favors something on the order of an explanation advanced by Von Weizsäcker in which he postulates that a vast cloud of dust and gas originally collapsed to form the central regions and disk of the galaxy and that portions of the material remaining behind in the outer regions consolidated to form the globular clusters. This view looks upon the clusters as essentially permanent features of the galaxy.

In the theoretical universe developed from the postulates of the Reciprocal System, stellar aggregates identical with the globular clusters also make their appearance, but these clusters originate uniformly throughout space. Once formed, they are pulled into the galaxies by gravitational forces. On this basis each of the larger galaxies is necessarily surrounded by a large number of globular clusters which are simply in the process of falling into the galaxy. When they reach the galactic disk they will be broken up by the rotational forces, first into smaller aggregates — galactic clusters — and finally into individual stars that will be absorbed into the general structure of the galaxy.

Here we have two very different views as to the origin and ultimate destiny of the globular clusters, one derived from astronomical

observations interpreted in the light of current cosmological theory; the other derived from a theoretical system developed in an entirely different physical field, but presumably applicable to the entire universe. For convenient reference we will designate these as the CA (current astronomical) and RS (Reciprocal System) theories respectively. Now let us look at the evidence, specifically those facts on which the two viewpoints differ, and which are therefore relevant for the purpose of supporting a decision as to which viewpoint is more in harmony with existing knowledge.

1. In spite of the observational difficulties involved, a substantial number of globular clusters have been located in inter-galactic space in recent years.[97] The existence of so many clusters not associated with galaxies is very awkward for a theory such as CA which regards these objects as having originated jointly with the galaxies, and the observed situation is therefore highly favorable to the RS theory, with which it is entirely in agreement.

2. The cluster system surrounding our galaxy does not participate in the galactic rotation.[98] This is difficult to reconcile with the CA theory. If the clusters were formed as a part of the galactic aggregate, then they should act as part of the galaxy and should participate, at least to some degree, in its motion. On the other hand, the RS theory says that the clusters are not part of the galaxy but are external objects that are being drawn in by gravitation. On this basis the reason why they do not participate in the galactic rotation is obvious.

3. The observed motions of the clusters are, in themselves, practically conclusive evidence of the validity of the RS theory. As Struve expresses it, the clusters move "much as freely falling bodies attracted by the galactic center."99 The RS theory says that this is exactly what they are, and that the observed motions are therefore just what we should expect. The CA theory views the observed paths as portions of extremely elongated orbits, but has no explanation as to why the cluster motion should have this highly abnormal characteristic.

4. Clusters closer to the galactic center are somewhat smaller than those farther out. Studies indicate a difference of 30 percent between 10,000 parsecs and 25,000 parsecs.[100] This is not necessarily inconsistent with the CA theory, but it is something for which that theory has no explanation, whereas it is definitely required by the RS theory, as the clusters are subject to more loss of stars by differential

gravitational forces as they move in closer where those forces are stronger. On the basis of the CA theory the present distance of a cluster from the galactic center has no special significance, since the observed position is merely a point on an orbit, and hence there should be no correlation of distance with size or any other cluster characteristic.

5. Some clusters (M67, for example) resemble galactic clusters in size, shape and location, but resemble globular clusters in the types of stars which they contain, and therefore have H-R diagrams similar to those of the globular clusters.[101] The existence of hybrid clusters of this kind is very difficult to account for in terms of the totally different cluster origins pictured by the CA theory. The RS theory gives a simple and straightforward explanation. It identifies M67 and others with the same general characteristics as former globular clusters, or parts thereof, which have only recently reached the galactic disk. The modification of the cluster structure under the influence of the strong rotational forces of the galaxy is already under way, but the evolution of the individual stars has not yet gone much beyond the globular cluster stage. The status of M67 as a recent arrival in the disk is corroborated by the fact that, if it is classified as a galactic cluster, it is one of the most populous of these units and one of the highest above the galactic plane.

6. The observed motions of the stars in the galactic clusters show that these groups are not stable and are breaking up at a relatively rapid rate. The large number of such clusters now in existence in spite of the short indicated life means that some process of replenishment of the supply must be operative. The RS theory says that the supply of galactic clusters is continually being replenished by globular clusters, which fall into the galaxy and are broken up by the rotational forces. This is the *only* adequate explanation that has ever been advanced, and since the current thinking of the astronomers does not permit them to accept it (although Bok and Bok, who discuss the question at some length, concede that it would be "tempting" to do so) they are forced to admit that "We do not pretend to know from where the (galactic) clusters came."[102]

The striking fact is that wherever the data obtained from observation favor one explanation over the other, they invariably indicate that the RS theory is correct. Why then do the astronomers

persist in their support of an explanation, which conflicts, with so much of the available knowledge in their own field? It is true that the astronomical profession has been inclined to favor theories that envision formation of galaxies as complete units rather than theories which build them up by some kind of an aggregation process, but it does not deny the possibility that the latter may be correct, and it recognizes cosmological theories incorporating the aggregation hypothesis—the Steady State theory advocated by the Cambridge group of astronomers, for example—as legitimate speculations, hence this preference is not sufficient to explain the blind allegiance which is given to the CA theory. What has actually happened is that the astronomers have rejected the evidence from their own observations and have turned their backs on simple and logical explanations which they admit they are "tempted" to accept, solely in order to conform to an unsupported assumption that has been made by another group of scientists in another field of science. This is one of the most astounding situations in all scientific history.

The crucial issue in this case is the direction of stellar evolution. There is ample evidence to indicate the existence of some kind of an evolutionary process in which certain characteristics of the stars change with time, but this evidence, by and large, merely shows that such an evolutionary pattern exists; it does not identify the direction of the evolution. There are, however, some purely astronomical methods by which this direction can be indirectly determined. One of the most unequivocal and positive answers can be obtained from a study of the galactic clusters. The evolutionary status of the individual clusters covers practically the entire known range of stellar types, extending all the way from groups composed of stars similar to those in the globular clusters (example—M67) to clusters composed largely of hot blue and white stars (example—the double cluster in Perseus). The question, then, is, Which is the young cluster and which the old?

We can answer this question by examining the density of the clusters. There is no doubt but that these galactic clusters are expanding; the motions are rapid enough to be measured. Their density is thus decreasing with age. Furthermore, the short lifetimes of the existing clusters preclude the possibility that either the average size or the average density of such a cluster as originally formed has changed materially during the time interval involved. It therefore follows that the clusters with the higher average density are the younger and those

with the lower average density are the older. Studies show conclusively that the clusters of the M67 type have the higher average density,[103] hence these are the young clusters and the clusters of the Perseus type are relatively old. The same studies also show that the average young M67 type cluster is located higher above the galactic plane than the average Perseus type cluster, which is just what would be expected if these clusters are formed by the disintegration of globular clusters that fall into the galaxy, in accordance with the RS theory.

But these simple, straightforward and consistent conclusions from *astronomical* evidence are summarily rejected by the astronomers purely on the ground that they conflict with the physicists' conclusion that the source of energy in the stars is the conversion of hydrogen to helium. If the physicists' theory of stellar energy generation is correct, the hot blue and white stars must necessarily be relatively young, since their supply of hydrogen "fuel" could not last long at the rate they are emitting energy. On this basis the Perseus type clusters, which are made up largely of such stars, must be very young. Many astronomers are not too happy about this conclusion. As expressed by Bok, "It is no small matter to accept as proven the conclusion that some of our most conspicuous supergiants, like Rigel, were formed so very recently on the cosmic scale of time measurement."[104] But rather than challenge the conclusions of the physicists, the astronomers have stifled such thoughts, ignored the evidence from their own field, and meekly acquiesced in the line of thought dictated by the physicists.

Even if the physicists were able to produce some very strong evidence in support of their conclusions, such submissiveness on the part of the astronomers would be surprising enough, but the fact is that the physicists have no such evidence to offer. The hydrogen conversion process is pure assumption. There is no actual evidence that such a process ever takes place in the stars or anywhere else. The unstable isotopes of hydrogen can be stimulated in such a manner as to cause them to do rapidly what they will do of their own accord sooner or later in any event, and the stable isotope can be forcibly altered—that is, by the expenditure of energy—but there is no observational or experimental justification for the belief that the stable isotope can be caused to become unstable. The mere fact that the conversion process would be exothermic, or exoergic, if it occurred, does not necessarily mean that it will take place spontaneously. Endothermic processes are familiar features of our physical world. The controlling factor is the

relative probability, not the energy balance, and, so far as we know, the hydrogen atom is just as probable a structure as the helium atom under any physical conditions.

The physicists' conclusions in this instance have been based on (1) the difference in mass between four hydrogen atoms and the one helium atom that would be formed by their combination, a difference which indicates that the hydrogen conversion process, if it could and did take place, would furnish at least approximately the kind of a source of energy that the observed output of radiation from a normal type star requires, and (2) the lack of any known alternative. If the explanation thus produced were completely in harmony with the known facts, it might be quite acceptable in spite of its dubious foundations, at least on a tentative basis, but even without the direct contradictions that were discussed earlier, the hydrogen process, as Bok says, does not satisfactorily explain the enormous energy output of a star like Rigel. E. J. Öpik not only agrees that "a more powerful source of energy must be assumed" for the giants, but also questions the applicability of the hydrogen process to the white dwarfs.[105] The strong astronomical evidence indicating that the direction of stellar evolution is opposite to that which would necessarily exist if hydrogen is the stellar "fuel" merely adds further emphasis to a conclusion that is already implicit in such shortcomings as those cited by Bok and Öpik: the conclusion that the hydrogen conversion process is *not* the source of stellar energy. If we must have a "more powerful energy source" for the giants, this can take care of the normal stars as well; we do not need two different processes.

An explanation of the much different energy generation process derived from the postulates of the Reciprocal System is beyond the scope of this volume. The objective of this present discussion is to show how the theoretical picture of the universe obtained from the new system exposes the weaknesses of existing theory, clarifies doubtful points, and enables fitting current astronomical knowledge into a consistent and logical pattern. The alternative process for generation of stellar energy, a full description of which has been published elsewhere, is, of course, entirely in harmony with this new astronomical pattern. It provides abundant energy not only for the supergiant stars but also for the novae and supernovae as well, and it results in an evolutionary sequence that conforms to the astronomical evidence in all respects.

Application of the powerful new RS instrument to such a study of the globular clusters thus gives us a quite different picture of these structures and their relation to the astronomical universe in general. This study also furnishes a demonstration of the second type of contribution, which the Reciprocal System makes to astronomical knowledge: the formulation of the new physical concepts that are necessary for the understanding of certain astronomical phenomena that are otherwise inexplicable. The answer thus supplied to the hitherto puzzling question as to why these globular clusters hold together but do not collapse into a single mass was, however, explained in detail in *Beyond Newton,* and a different illustration will therefore be discussed in this work. As a background for this presentation, let us look at the matter of physical separation between objects.

If a number of objects that were originally in contact move outward in space away from each other, they are then separated by intervals of space. Because of the symmetry of space and time, it is also possible for objects to move outward away from each other in time, and as a result of such movement the objects are then separated by intervals of time. When expressed in this manner, the foregoing statement seems commonplace enough, but in the first example we say that the objects are now separated by *empty space,* and it follows that the second group of objects are now separated by *empty time:* a concept which is likely to seem little short of outrageous to those who are accustomed to staying within the bounds of conventional thought.

Our initial emotional reactions are, however, definitely untrustworthy when we are undertaking to examine new ideas. Good scientific practice requires that we should test these new ideas, if possible, rather than jump to conclusions without adequate factual grounds. Inasmuch as the presence of empty time in any material aggregate will have a striking effect on the properties of such an aggregate, one possible way of testing the validity of the conclusion as to the existence of empty time is to look for objects that possess these extraordinary properties. If such objects can be located, their existence then constitutes strong evidence in support of the deductions that have been made from the underlying theory.

Since empty time is the antithesis of the empty space that plays such a prominent role in our local environment, the most likely place to find empty time is in some distant object existing in relative isolation;

that is, an isolated astronomical object. And in order to be visible for our examination, such an object will have to be self-luminous. In other words, we are looking for a special and very peculiar kind of star. Let us see just what properties this star should have.

By way of contrast, we will look first at the properties of a star containing a maximum amount of empty space. Such a star has a very large diameter, a very low density, and because it is radiating from a surface area that is very large compared to the stellar mass, its surface temperature is relatively low, giving the star a dull red color. From these characteristics the star derives its name; it is a red giant, a member of a stellar class well known to astronomers. If we now substitute for this maximum amount of empty space an equivalent amount of empty time, the stellar characteristics are radically changed. Inasmuch as more time, according to the reciprocal postulate, is the equivalent of less space, this star has a very small volume and an extremely high density. Since it is radiating from a relatively small surface area, the surface temperature is high and the color is blue or white.

Are there any such stars? There are. Millions of them in our galaxy alone, astronomers estimate, on the basis of the relatively large number found within the distance at which such objects are visible. The strange stars known as the white dwarfs have exactly the characteristics described: small diameter, comparable to that of a large planet, fantastically high densities, far out of the range of anything known elsewhere in the universe, and a high surface temperature, giving these stars a white color. A significant point in this connection is that the order of magnitude of the maximum deviation of the density of these white dwarf stars from the normal density of solid matter is just about the same as that of the maximum deviation of the density of the red giants in the other direction; that is, the extreme white dwarf contains just about as much empty time as there is empty space in the extreme red giant, as would be expected from the space-time symmetry principle.

Of course, present-day physical theory also has an explanation of sorts for the peculiar characteristics of the white dwarfs. This theory postulates that the high density of the dwarfs results from a collapse of the atomic structure that allows the atomic nuclei to pack together in a solid mass. As brought out in *The Case against the Nuclear Atom,* the so-called atomic "nucleus" is purely fictional, but even if atoms did have a nuclear structure, current theory has no plausible explanation

of why the "collapse" occurs. The proponents of the theory talk vaguely about the lack of support at the center of the stellar mass after the star's "fuel" has been exhausted and the atoms no longer have sufficient kinetic energy to maintain the normal gaseous relations. But there is no adequate explanation as to why this situation, even if it did exist, should affect the internal relations within the atoms. The atoms at the center of the star are subject to the full pressure due to the weight of the overlying material in any event, and the exhaustion of the hydrogen "fuel", would not change this situation. Actually the compressive force acting against the central atoms should be somewhat less at the time of exhaustion of the hydrogen than it was previously, if the evolution of the star takes place as assumed, since the superimposed weight would be reduced by the amount of mass radiated away.

Furthermore, there are other astronomical facts that even the proponents of the "collapse" theory admit are irreconcilable with the theory, on the basis of present knowledge. One of the most obvious of these is the common occurrence of binary stars, which consist of giant-white dwarf pairs. If the white dwarf status is the result of advanced age, as the theory contends, then it is entirely out of order for such a star to be paired with a theoretically much younger type of star in a combination whose components, in all probability, must have originated contemporaneously. An isolated case of this kind might be explained as a freak, but these giant-dwarf pairs are familiar features of the stellar universe. In view of its inability to account for such phenomena, together with the complete lack of any logical explanation as to why there should be any internal collapse of the atom, the current theory can hardly be considered a satisfactory product.

The "empty time" explanation, on the other hand, is simple and logical, and it agrees with the astronomical observations easily and naturally. On the basis of this theory, it is not necessary to postulate any unusual or extraordinary events such as an atomic "collapse" to account for the characteristics of the white dwarfs. The very high density of the dwarfs, this theory says, is exactly the same kind of a phenomenon as the very low density of the giants, the only, difference being that the separation between the atoms in one case is in time, while in the other case it is in space. The giant-dwarf combinations, which have been such a stumbling block for previous theories are then easily accounted for, as there is nothing to prevent

the simultaneous production of stars, which differ only in the nature of the separation between the constituent atoms. Indeed, it will be shown in Chapter XIV that such pairs are not only possible, but *normal* developments.

It should also be noted that the currently accepted explanation is entirely *ad hoc*. There was no advance intimation in physical theory of the existence of any such structures as the white dwarfs; on the contrary, the first reports of the observations made on Sirius B were met with disbelief, and their validity was conceded only after so much confirmatory evidence became available that further resistance to recognition of the facts was virtually impossible. The explanation now in vogue is not something that developed naturally out of the preexisting structure of theory; it is simply the best the theorists could do in the way of meeting an awkward situation which was thrust upon them by the findings of the men in the observatories. There is no reason to believe that any such theory as that of "atomic collapse" would ever have appeared if the white dwarfs had not first been located by astronomical observations.

On the other hand, it is clear that the postulates of the Reciprocal System demand the existence of such structures as the white dwarf stars. As long as material aggregates exist in which the constituent atoms are separated by empty space, the symmetry principle makes it impossible to avoid asserting the existence of material aggregates in which the constituent atoms are separated by empty time. There will no doubt be a tendency to question the foregoing statement on the ground that it is a product of hindsight, which is notoriously much more clear than foresight, but the recognition of inverse relationships of this kind has been an important feature of the development of the Reciprocal System and initial presentation of this system in *The Structure of the Physical Universe,* published in 1959, contained *many* predictions based on this same symmetry principle which asserted the existence of phenomena then wholly unknown to science.

Some of these predictions have actually been verified in the meantime. Included among them was one, which required the existence, somewhere in the universe, of events millions of times more energetic than the most violent explosions then, known to science. In view of the radical nature of this prediction and the incredulity with which the astronomers received it, its subsequent verification

is one of the highlights of the short history of the Reciprocal System, and we are justified in designating this as number nine in the list of Outstanding Achievements of the system.

In the 1959 publication the exact structure of the compound motions that constitute the atoms of the chemical elements was worked out in detail, and the nature of the process by which the more complex elements are built up from smaller units was determined. Further study of this process then disclosed that it must ultimately terminate in the destruction of matter, which reaches a certain limiting degree of complexity. Since the building-up process is one which continues through time, this means that there is a limiting age of matter and, in turn, the existence of such a limit leads to the conclusion that the oldest and largest galaxies will end their careers in gigantic explosions.

The original text admitted "It must be conceded that this seems rather incredible on first consideration. The explosion of a single star is a tremendous event; the concept of an explosion involving billions of stars seems fantastic, and certainly there is no evidence of any gigantic variety of super-nova with which the hypothetical explosion can be identified." But the text insisted that these explosions must nevertheless occur, even though nothing of the kind had ever been identified, as their existence was "an inescapable deduction from the principles previously established." It also went on to point out that there actually was one observed phenomenon which could very well be the result of the kind of an explosion predicted by theory, even though it was not currently viewed in that light:

> In the galaxy M87, which we have already recognized as possessing some of the characteristics that would be expected in the last stage of galactic existence, we find just the kind of a phenomenon which the theory predicts, a jet issuing from the vicinity of the galactic center, and it would be in order to identify this galaxy, at least tentatively, as one which is now undergoing a cosmic explosion, or strictly speaking, was undergoing such an explosion at the time the light now reaching us left the galaxy.[106]

When it was originally published this prediction was rejected by the astronomers as utterly fantastic; now they are frantically trying to find an explanation of their own for recently discovered phenomena of exactly the kind predicted. However incredible the existence of explosions millions of times more energetic than the super-nova explosions of single stars may have seemed in 1959,

today's observations leave little doubt but that such phenomena actually exist. Additional studies made on the jet issuing from M 87, notably by I. S. Shklovsky, have confirmed the conclusion that this is an actual ejection of fast moving particles, and have determined that the energy of the jet is enormous. "What is the nature of this phenomenon?" Shklovsky asks, and answering his own question he goes on to say, "It would be natural to think of some explosion of grandiose proportions, exceeding by far even such exceptional phenomena as supernova outbursts (the energy of this explosion would exceed that of a supernova by a factor of about 10^7…).[107] But the explosion explanation was still too radical and Shklovsky gave it scant consideration at the time. Not until about 1961 was this hypothesis actually taken seriously. In September of that year a note in the Scientific American reporting on recent suggestions that galactic explosions might be taking place begins with this comment:

> What is the origin of the prodigious quantities of radio energy emitted by the radio "stars" outside the Milky Way? A few years ago it was generally agreed that the power came from collisions between galaxies. Since then this explanation has begun to seem more and more dubious, and radio astronomers are now casting about for another mechanism.[108]

Since then the evidence confirming the existence of exploding galaxies has grown rapidly. A recent report by Allan R. Sandage lists a number of galaxies from which jets similar to that of M87 are issuing, and describes observations on the galaxy M82 which are apparently conclusive evidence that "the galaxy was the scene of such an explosion some 1.5 million years ago."[109]

Observational verification of a prediction that ventured so far off the beaten track is, of course, a major triumph for the Reciprocal System, particularly since this conclusion was not the product of a fertile scientific imagination but was reached by means of logical reasoning from basic premises established in other fields of science. But this is not the whole story. The development of the theoretical RS universe did not stop with the explosion. It went on to determine what happens to the material scattered by the galactic explosions, and it concluded that, after some intervening steps, this material manifests itself in the form of the cosmic rays. All this was brought out in detail *in the 1959 publication.* Now, many years later, the

astronomers are just getting around to taking suggestions of this kind seriously. "Evidence of a titanic explosion in the nucleus of a nearby radio galaxy suggests that such events may be responsible for a large part of the cosmic radiation striking the earth," is the summary, which introduces Sandage's article.

But even though the astronomers are finally arriving at some of the conclusions that were published in *The Structure of the Physical Universe* in 1959, the Reciprocal System is *still* one jump ahead of them, as they were unprepared for the discovery of the exploding galaxies and this discovery has confronted astronomy with a serious problem in accounting for the origin of the tremendous amounts of energy generated in these events. As Sandage says, "It is obvious that conventional energy sources are not adequate to explain the phenomena we are now observing, and some totally new energy principle may have to be devised." The Reciprocal System is not embarrassed in this way because it is not, like the astronomers, groping around in the dark trying to find an explanation for an observed phenomenon. The existence of this phenomenon was deduced from the fundamental principles of the new system long before it was verified observationally, and in a deductive process of this kind the *reasons* precede the conclusions; they do not have to be the object of a search after the conclusions are reached. The theoretical discovery that matter, which reaches limiting values in the centers of the oldest galaxies would suddenly release an immense amount of energy, was the *basis* for the conclusion that these galaxies would explode.

Although neither the astronomers nor the physicists seem to have recognized the point as yet, this need for a "totally new energy principle" cuts the ground out from under the currently accepted hypothesis that the conversion of hydrogen to helium is the source of stellar energy. Inasmuch as this conversion process is purely hypothetical, without any experimental or observational evidence to back it up, the principal argument in its favor has always been the lack of any alternative process capable of producing the required amounts of energy. The conclusion voiced by Opik that we must find "a more powerful source of energy" for the giant stars has already seriously weakened this argument, and Sandage's admission that a totally new energy process must be found to account for the energy output of the galaxies now administers the *coup de grace.*

The major problems of astronomy and cosmology, including the cosmic ray situation, will be discussed later in this volume after some necessary foundations have been laid, but this present chapter was placed here in order to introduce the concept of empty time as a typical and rather striking example of the kind of new concepts which will be encountered in the subsequent pages, and which must be clearly understood before the full significance of the theoretical arguments can be grasped. The concept of empty time is wholly foreign to present-day thought, and in the context of this structure of thought it seems absurd, but a careful examination discloses that this impression is created only because the idea conflicts with some of the usual *assumptions* as to the nature and properties of time.

Modern science has sacrificed so many basic principles for the sake of new physical theories of its own devising that it is now in a rather poor position to object to any new idea or concept as a matter of principle. A profession that can give up the concept of absolute magnitudes for the benefit of Relativity, that can give up the idea of causality for the benefit of quantum theory, that can give up the idea of the objective reality of atoms and particles for the benefit of modern atomic theory, and that can seriously consider giving up the principle of conservation of matter (or matter-energy) for the benefit of the Steady State theory of cosmology, can hardly be taken seriously if it attempts to stand firm on basic principles at this late date. But the truth is that no basic principles are involved in this case. The new development simply shows that the prevailing assumption that time is one-dimensional is erroneous, and that it is actually three-dimensional. Everything else then follows as a matter of course. The existence of empty time is then logically possible and a theory incorporating this concept has the same logical standing as one that conforms to previously existing patterns of thought.

The next five chapters will introduce a number of new concepts which are at least as foreign to current thinking as the idea of empty time, and may even seem more bizarre on first consideration. Here again, however, the basic situation is the same. On the initial contact with these ideas they appear strange–weird, perhaps–not because they are inherently illogical or absurd, but simply because they, like the idea of empty time, conflict with some of the *assumptions* concerning the nature of space and time which have remained

unchallenged for so long that their true status has been forgotten. What is now necessary is to go back and correct the erroneous basic assumptions and then to adjust the prevailing directions of thinking accordingly. It should be remembered in this connection that when there are difficult problems to be solved some change in existing ideas is imperative, and if the problems are of long standing, the necessary change is likely to be a major one.

CHAPTER XI

The Two Aspects of Motion

To Aristotle space represented a *relationship* between objects, to Democritus it was a *container* in which the objects exist, to Einstein it was a *medium* connecting the objects. Modern science professes to follow Einstein, but in practice adopts a kind of hybrid viewpoint. Indeed, it is quite fashionable to contend that Einstein eliminated the need for a medium, even though it is clear that his "space" has all of the properties, aside from that of being a material substance, that are ever assigned to a hypothetical medium, and he unquestionably uses it as a medium in his theoretical structure. In fact, Einstein himself admits that his "space" is the equivalent of an "ether" and specifically uses the word "medium" to describe it.[110]

The findings of this work now assign a still different role to space. In the Reciprocal System, space is an *aspect of motion.* For the purpose of this description, however, we must visualize motion in a somewhat more general sense than that in which the term is customarily utilized. Ordinarily we conceive of motion as motion of something. However, the mathematical equations by means of which we describe the motion show no trace of this something, whatever it may be. The equation v = s/t, for instance, defines velocity, the quantitative measure of motion, in terms of space and time only, without bringing anything else into the picture. In this equation it is clear that motion is a relation between space and time—nothing more—and when this work describes space as an aspect of motion, this is the significance that is attached to the term "motion."

The principal purpose of specifying that a particular motion is a motion *of* a particle or *of* something else is to identify the space-time and velocity with which we are dealing. In some instances it is possible to identify particular units of space and time independently of any moving object, and the relation of space to time under these conditions is also motion: a more generalized motion, we may say.

Space is one aspect of motion, whether that motion is motion of something or not, and time is the other aspect.

When we are dealing with translatory motion, space manifests itself as extension. This is the familiar entity that we normally visualize whenever the term "space" is used. Hearing or seeing this word calls to mind a linear extension, an area, or a volume, depending on the context. For purposes of convenient reference we will hereafter apply the name "extension space" to this kind of space, irrespective of the dimensions involved. Extension space is the only kind of space that exists in the world of Aristotle, the world of Democritus, or the world of Einstein. When we characterize space as an aspect of motion, however, we introduce other kinds of space, since motion can be vibrational or rotational as well as translational, and one of the two reciprocal aspects of this vibrational or rotational motion is space, as herein defined, even though such space does not constitute extension in the normal sense of that term.

There is a somewhat general tendency to object to this new definition of "space" on the ground that it involves lumping together under one designation several entities of quite different character and is thus nothing but an artificial grouping without any physical justification. The truth, however, is just the opposite. This is the definition that conforms to the physical realities; that is, the physical principles applicable to space in general apply not only to extension space but also to the other kinds of space included within this definition. Hence this is the definition that *must* be used in order to arrive at the correct physical results.

As pointed out in the earlier discussion, the common practice of setting up definitions on a purely arbitrary basis or in conformity with prevailing viewpoints regarding the items to be defined, rather than making a serious effort to fit the definition to the physical situation, is a serious obstacle in the way of scientific progress. It is often stated that no definition can be wrong if it is logically formulated and consistently applied, and in a sense this is true. But such a definition is not automatically applicable to a physical situation. In order to be fully effective any definition of a *physical* quantity must conform to the *physical* realities; that is, the definition must include everything that behaves in the same manner physically, and it must exclude everything that behaves in a different manner. The general properties of the space component of rotational or vibrational motion are

identical with those of extension space, and where both are present, the total space is the sum of the two.

The meaning of the foregoing statement is rather difficult to grasp because of established habits of thought which preclude the kind of a concept that is here being advanced, but consideration of an illustrative example may be of some assistance. Let us assume that a rotating particle of atomic dimensions exists in a specific location in space and time, and then let us ask, What effect does the presence of this particle have on processes that take place in the extension space at this location? According to the views of Democritus and Newton, there is no effect at all, since space is simply a container in which the particle exists, and unless the particle exerts some kind of a force on the participants in the hypothetical process, a possibility which we are excluding from consideration, it is merely something that is also present in the vicinity. Einstein asserts that inasmuch as the particle has mass, it distorts space-time in its vicinity. The Reciprocal System rejects Einstein's contention and agrees with Newton that the "container" space is not affected by the existence of the contained particle, but this system asserts that if the particle is rotating with a space displacement, as defined in Chapter VI, then the total space involved in the hypothetical process is the sum of the extension space (the space of the container) plus the space displacement of the rotation. If the particle is rotating with a unit displacement, the space aspect of this rotation constitutes one unit of space, and the total space taking part in physical phenomena in this vicinity is increased by one unit.

In order to see what this means, let us now assume that a beam of light passes through an aggregate in which particles of this kind are present. According to the new theory, the additional space will reduce the apparent velocity of the light beam, when this velocity is measured in the usual manner. The true velocity has not changed. The photons of which the radiation is composed have no motion of their own, and consequently they are at all times and all places carried forward at unit velocity—the velocity of light in vacuum—by the progression of space-time. Interposition of the rotating particles cannot change the velocity of anything which is incapable of moving at all with respect to space-time, and the true velocity of the photons must therefore remain at the velocity of space-time itself, one unit of space per unit of time. However, the presence of the *additional* space of the rotating particles increases the total amount of space

to be traversed by the radiation and therefore increases the time required to traverse a given amount of linear extension. This means a lower velocity on the usual basis of measurement, which takes into account only the extension space. Rotating space displacements are included in the structure of most atoms of matter and, accordingly, we find that the velocity of light in a material medium is less than c, the velocity in a vacuum.

Another interesting and important phenomenon that is made possible by the existence of rotating space displacements is the movement of space through matter. The concept of such a movement is, of course, wholly foreign to the traditional ideas as to the nature of space and of matter, but once we recognize space as an aspect of motion it becomes evident that the space aspect of rotational motion has some possibilities that are altogether out of the question so far as extension space is concerned. A rotating space displacement is entirely independent of extension space. It cannot move with respect to that space, since the relation of these two entities is a relation of space to space, which is not motion, but it can move with respect to a time structure, as the relation of the rotational space displacement to this structure is a relation of space to time, which is motion. Detailed studies of the nature and characteristics of the atoms of matter which were reported in previous publications have shown that the net displacement of these material atoms is in time, and matter therefore constitutes the type of a structure in which rotating space units are able to move.

The simplest rotating space unit is one that is formed by direct addition of one-dimensional rotational space displacement to the basic vibrating unit. As indicated on Chart B. the compound unit of motion thus derived in the theoretical RS universe is identified as an electron. It is not the kind of an electron that is observed as an individual particle in space, however, as the latter is electrically charged, whereas the theoretical particle, in its normal state, is uncharged.

The relation between the electric charge and the experimental electron has been subject to much difference of opinion in scientific circles ever since this particle was originally discovered. One school of thought has held that the charge is the essence of the electron, and that the so-called particle is in reality nothing more than a free electric charge. Modern opinion tends to favor the view that the electron as observed is actually a particle *with* a charge, but whether or not it

is ever possible for the electron to exist in an uncharged state is a matter of controversy. The uncharged or "bare" electron is a feature of many current theoretical speculations, but some physicists take a dim view of it. Dirac, for instance, calls it an "unphysical concept" and suggests that "Probably in the improved physical picture we shall have in the future the bare electron will not exist at all."4

Now that the Reciprocal System makes an "improved physical picture" available, however, the uncharged electron emerges as an important feature of this picture. In the RS universe it is the movement of these uncharged electrons through matter that accounts for the theoretical phenomenon corresponding to the electric current, as well as for the conduction of heat.

It has been recognized ever since the first discovery of electrical phenomena that there are some marked differences in behavior between static electricity and current electricity, and the early investigators were undecided as to whether these were two different phenomena or merely two different manifestations of the same thing. But when it was found that a flow of static charges produced the same magnetic effects as a flow of the current generated by a Voltaic pile, the supporters of the unitary hypothesis gained the upper hand, and since the days of Faraday the electric current has been regarded as a flow of charges or charged particles. Subsequently the hypothetical charged particles were identified as electrons.

However, the general acceptance of this theory that current electricity is simply static electricity in motion has been based on the discovery of points of similarity between the two phenomena, not on any plausible explanation of the observed points of difference. The behavior of static charges in motion is not the same as that of an electric current, and the behavior of a conductor raised to a high electric potential from a source of current is not the same as that of an object with a large static charge. For example, the inductive effects of a potential from a current source are very minor compared to those that would be experienced from an equivalent static charge. Then, again, the static charges repel each other and are therefore located on the surface of the charged object, whereas the direct relation of the conductivity of a conductor to its cross-sectional area indicates that no such effect is present in current electricity. This latter point is, in itself, strong evidence that the particles, which constitute the current, are not charged.

At this juncture it may legitimately be asked why these arguments, none of which is actually new, should carry any more weight now than they have done in the past. The answer is that the question now at issue is altogether different from what it has been previously. Up to this time there has been only one plausible theory available, and the question has been; Is there enough support for this theory to justify accepting it and utilizing it for the time being? Obviously this question had to be answered in the affirmative, as there are many items of evidence that lend credence to the charged particle theory. Probably the most convincing of these, aside from the magnetic effects previously mentioned, is the fact that where a current originates in an electrolytic solution, passes through a conductor, and returns to the solution, the current moving through the solution is undeniably being transferred by charged particles, or charged units of some kind. From this it seems reasonable to assume that a movement of charged particles also exists in the external conductor.

But now we are confronted with a totally different question. A new theory has appeared to challenge the theory of the charged particle, and the question now is; Which of these theories is correct? In this context all of the weaknesses and contradictions that could be overlooked when the charged particle theory had the field all to itself become strong arguments against that theory, since the new theoretical system is in agreement with *all* of the known facts or, at least, is not inconsistent with any of them. Under the circumstances the charged particle theory is no longer tenable.

In view of the sharp distinction which the new system makes between those phenomena which involve electric charges and those which are due to the presence of uncharged electrons, the subjects that are customarily treated under the general heading of electricity will have to be separated into two groups for present purposes. A discussion of the electrolytic process and other items involving electric charges will be postponed until after the general nature of these charges is explained in the next chapter. At this time we will take a brief look at some of the important features of the electric current as we find it in the theoretical RS universe.

One of the most significant conclusions of this new development is that the electrons move not through the space between the atoms. In this connection, it does not seem to have been recognized that there is a serious weakness in the present-day theory that views the electrons

as moving through the interstices between the atoms, since this does not explain why the current is confined within the conductor. If the electrons can move readily through the spaces between the atoms, then there is no visible reason why they should not move through the spaces between the outside atoms of the conductor and thus escape out into the surrounding space. An attempt has been made to explain this situation by means of another demon (that is, an *ad hoc* force invented for this specific purpose). It has been postulated that a "potential barrier" at the surface of the conductor prevents escape of the electrons, and the existence of surface forces which keep the atoms of a liquid confined within the aggregate until they acquire a certain minimum amount of kinetic energy is often cited as an analogy which supports this hypothesis. Shortley and Williams, for example, give us this explanation:

> Electrons within a metal can be regarded as "free" so far as electric current within the metal is concerned, but they are confronted by a "barrier" at the surface of the metal. In order to escape from the metal, an electron must have sufficient energy to pass through the surface barrier. The minimum energy an electron must have in order to escape may be called the "height of the potential barrier" at the metal surface.... The escape of electrons from a metal is quite analogous to the escape of the molecules of a liquid in evaporation, where there are also barrier forces tending to prevent the escape.[111]

The flaw in this analogy is that there is a known force which accounts for the "barrier" to evaporation—the cohesion between the molecules of the liquid, which is effective not only at the surface but throughout the liquid aggregate, as can easily be demonstrated by suspending a liquid drop from a solid surface—but there is no known force of cohesion between the electrons. Indeed, they should repel each other if they are charged, and in that event the "potential barrier" comparable to that which exists in the liquid should be negative. Neither is there any evidence of a force of cohesion between the electrons and the atoms of matter, nor could there be any such force without offering the same resistance to passage of the electrons *through* the conductor as *out of* the conductor.

This explanation thus turns out to be one of those false analogies that are based on casual and superficial consideration of the phenomena in question without any adequate effort to examine the validity of the assumption that they are of a similar nature. The "barrier" to the escape of a liquid molecule by evaporation is a genuine restraining

force whose existence can be demonstrated independently of the evaporation phenomenon and whose magnitude can be measured. The "barrier" to the escape of an electron from a conductor is purely hypothetical; it cannot be a restraining force of the same nature as that which holds the liquid molecule back, and there is no reasonable suggestion as to any other way in which such a barrier might originate.

In the theoretical RS universe there actually is a barrier preventing escape of the uncharged electrons, but it is not merely a hurdle comparable to the force that resists evaporation; it is a *positive* barrier. An uncharged electron can move freely through the atoms of a conductor, but it cannot move at all through space, either inside or outside the conductor. Space (electrons) cannot move through space (extension) simply because the relation of space to space is not motion. But the uncharged electron can move through matter, because the net displacement of the material atom is in time, and the relation of space to time is motion.

What actually happens at the surface of the conductor is that if enough additional energy is imparted to the electron by any one of a number of possible mechanisms—thermal excitation, electrical potentials, high energy photons, etc.—the electron acquires a charge, and in the charged condition it is able to move through *either* time or space, for reasons which will be explained in the next chapter. The energy required to expel the electron from the conductor is not used in penetrating a barrier but in creating the electric charge and in giving the charged electron sufficient kinetic energy to overcome the gas pressure in the ambient space. Evacuating the air can reduce this pressure, and most devices designed for the production of charged electrons therefore operate in a partial vacuum.

The general effects of motion of space (electrons) through matter are identical with the effects of motion of matter through space (extension). One of the most obvious results of the current flow is an increase in the temperature of the conductor. This is commonly attributed to frictional effects as the electrons make their way through the inter-atomic space, but since the electron moves through matter, not through the open spaces, such an explanation cannot apply in the RS universe. Here we find that passage of electrons (units of space) through a conductor is equivalent to a movement of the atoms of the conductor through the same amount of extension space. The motion of space (electrons) through matter thus adds to

the previously existing thermal velocity of the atoms — movement of matter through space (extension) — and since it is the total velocity that determines the temperature, one effect of the electron flow is to raise the temperature of the conductor.

The rate of transfer of energy from the electric current to the thermal motion of the atoms of the conductor is the factor which determines the amount of current flow that will take place in response to a given potential difference. It is expressed as *resistance*, the ratio of potential to current. As can be seen from the explanation in the preceding paragraph, a conductor has no resistance at all unless thermal motion is present. The electrons (units of space) can move through motionless matter freely without expenditure of energy, just as matter can move freely through open space. If thermal motion is present they increase the magnitude of that motion, but if there is no such motion to begin with the increase in space due to the current flow has no thermal effect. The resistance of a pure conductor is therefore zero at zero absolute temperature and it increases linearly with increase in temperature.

Although all material substances are basically time structures — that is, their net displacement is in time — they are not all equally good conductors of electricity, as most substances contain some space displacement, for reasons that will be explained in Chapter XVI, and where a substantial amount of space is involved the electrons either cannot pass through such substances at all or can do so only with a certain amount of difficulty (expenditure of energy). The various forms of matter therefore range all the way from very good conductors to substances, which are almost as effective insulators as space itself. Presence of small amounts of non-conducting materials in conductors often has a disproportionately large effect on the resistance, particularly at low temperatures, and the behavior of conductors containing impurities often deviates considerably from the theoretical pattern of the pure conductor. For instance, most conductors approach a finite value, the so-called "residual resistance" as they approach zero temperature rather than decreasing all the way to zero.

The rate of flow of the electric current, commonly designated by the symbol I, is expressed in terms which are equivalent to the number of electrons per unit of time. Inasmuch as each electron is a unit of space, what we have here is units of space per unit of time. This is the definition of velocity, hence the flow of current is a velocity.

Since the kinetic energy of matter moving through extension space is proportional to the square of the velocity, it follows that the thermal energy of an electric current (the heat developed by the current flow) is proportional to I^2. This conclusion is confirmed by experiment.

Electromotive force, or potential, is analogous, in its general aspects, to gas pressure, which is force per unit area. The magnitude of the potential at any point may be increased in the same manner that gas pressure is increased, either by introducing more electrons with the same average velocity or by imparting a greater velocity to the electrons already present. If we connect one end of a metallic wire to a battery or other source of electrons, the electrons which enter the wire from this source raise the potential at the point of entrance and cause a flow of current (electrons) until equilibrium is reestablished. Similarly, if one end of the wire is heated, the additional thermal velocity of the electrons raises the electric potential and causes a flow of current toward the other end of the wire. The immediate effect in this case is equilibrium between a lower concentration of high velocity electrons at one end of the wire and a higher concentration of low velocity electrons at the other end. Ultimately both the velocities and the concentrations will equalize if the wire is thermally isolated. In the usual situation, however, there is a thermal interchange between the wire and its environment. The high velocity electrons arriving at the cold end of the wire transfer part of their energy to the atoms of the wire in order to reach a thermal equilibrium, but the atoms continually destroy the equilibrium by losing heat to their environment. This means that the heat flow, or conduction of heat from one end of the wire to the other, unlike the flow of current from the battery, will continue as long as the ambient temperature at one end is greater than that at the other.

It has long been recognized that the movement of electrons in this manner is a very logical explanation of the metallic conduction of heat, but the obstacle that has prevented unqualified acceptance of this idea is the absence of any indication of the increase in specific heat which would seem to be required by the electron movement. The answer to this objection is now provided by the Reciprocal System. The thermal motion of the electrons, this new system says, is not an addition to the thermal motion of the atoms, as previous theory has assumed; it is an integral part of the total atomic motion. A mass m attains a certain temperature T when the thermal velocity

of its constituent atoms reaches a specific average value n. From this standpoint it is immaterial whether the velocity consists entirely of motion of the atoms through space (extension) or partly of such motion and partly of motion of space (electrons) through the mass. The total velocity v corresponding to the temperature T is the same in either case, hence the conduction of heat by movement of electrons has no effect on the specific heat.

Since the thermal characteristics of different kinds of matter vary considerably, it follows that the nature of the equilibrium between the motion of the electrons and the motion of the atoms of matter is also subject to substantial variations. In the absence of any externally generated electric potential the relative potential of the electrons therefore depends on the characteristics of the conductor. In general a low resistance conductor such as copper will have a lower electrical potential than a conductor with a higher resistance. If we place two such conductors in contact we therefore generate what is known as a *contact potential.* A flow of electrons will take place from zinc to copper, for example, until the density of the electrons in the copper becomes high enough to offset the greater velocity of the electrons in the zinc. The same differences between the equilibrium potentials in different materials are responsible for a number of other phenomena, such as the thermoelectric effect, the Peltier effect, the Thomson effect, etc., which are beyond the scope of this work but have been discussed in previous publications.

A hundred years ago one of the questions that loomed large in the thinking of scientists and laymen alike was: What is electricity? Today this question is seldom asked by laymen and almost never by scientists, not because it has been satisfactorily answered, but because scientists have been able to persuade both themselves and the general public that there is no answer; that electricity simply has to be accepted without explanation as something that exists. The Reciprocal System has now retrieved this question from the limbo into which it was cast, and has provided the allegedly non-existent answer: number ten in our list of Outstanding Achievements. This answer, the concept of space moving through matter, will no doubt be hard for many persons to accept, but this is only because the new concept of space itself seems so strange. *Homo sapiens* has not thought about space in this way, or looked at space in this way, before, and he distrusts the unfamiliar.

All that is necessary here is to recognize that space is an aspect of motion, and that extension space, the only space that has been recognized heretofore, is only one of the ways in which space may manifest itself. The space aspect of rotational motion is obviously something other than linear extension, and as soon as it is realized that this is actually space, in the same sense that extension space is space, the shock that usually accompanies the first encounter with such a seemingly bizarre concept as that of space moving through matter will wear off.

CHAPTER XII

Rotational Vibration

As brought out in Chapter IX, the addition of thermal or other translational motion to the compound units shown on Chart B. atoms and sub-atomic particles, gives these units some new behavior characteristics and a whole new set of properties—thermal and mechanical—emerges. But the nature of the changes that occur when the atom or particle acquires a translational motion is, in a sense, rather superficial, and the unit is still customarily regarded as the same kind of an entity whether or not it possesses motion of this kind. An atom in motion is simply a moving atom; it is not given any new name.

This is true of translational motion in general. It does not modify the behavior of the unit to which it is applied enough to justify considering the unit in motion as a unit of a different kind. In expanding Chart B we will therefore omit any reference to addition of translational motion. There is, however, a second kind of rotational motion which can be superimposed on the compound units previously discussed, and which will modify the properties of those units to such a degree that the products may be considered as belonging in a new category or, at least, a new subdivision of the original category. The motion which produces these results is rotational motion that periodically reverses direction; that is, rotational vibration.

Motion of this type plays only a relatively minor role in our ordinary experience. The escapement of a watch is an example with which we are all familiar, and many other mechanical devices include parts with a "rocking" motion of one kind or another but, in general, there is not enough difference between rotational and linear oscillations in such applications to justify making any special distinction between the two. At the level of atoms and particles, however, the effects of a rotational vibration are altogether different from those of a linear vibration. The reason is that the atom or particle is basically a rotating unit. The result of adding linear translation or vibration, motion of a

different nature, is to move the rotating unit, but rotational vibration is motion of the same kind as that which constitutes the basic structure of the unit to which it is applied, hence the result of adding rotational vibration is to *modify* the rotating unit.

In the detailed study of the rotational motion of the atoms of matter previously published it was shown that the three-dimensional rotation actually consists of a two-dimensional rotation and an oppositely directed one-dimensional rotation. The rotational vibration, which must necessarily oppose the rotation, may therefore be either one-dimensional or two-dimensional. The one-dimensional rotational vibration that exists in the theoretical RS universe can be identified with the physical phenomenon known as an electric charge. Such charges are easily produced in almost any kind of matter or subatomic particle and can be detached from these units with equal ease. In a low temperature environment such as that on the surface of the earth the electric charge therefore plays the part of a temporary appendage to the relatively permanent systems of rotating motion.

This view of the role of the electric charge in the physical universe which we derive by development of the consequences of the postulates of the Reciprocal System is, of course, a far cry from the prevailing opinion at present, which regards the charge as the very essence of all material things. "Almost all the phenomena we see around us in nature are based upon electric forces and their effects,"112 we are told.

But the amazing thing about this extraordinary glorification of the electric charge is that when we inquire into the particulars of the commanding position which the charge is supposed to occupy, we find that all of the really significant functions ascribed to the electric charge are those of *hypothetical* charges which cannot be detected by any direct means and which, if they exist as postulated, can exist only in defiance of the physical laws that the observed charges follow unfailingly. The electric charges that are known to exist participate in some interesting and important phenomena, to be sure, but not anything of a basic nature. Even the author of the statement quoted in the preceding paragraph admits, almost in the same breath, that we cannot detect any major effects of electric forces by direct observation. We find them only in theory. It is the purely hypothetical charges that are supposed to determine the structure of the atom; it is the purely *hypothetical* charges that are supposed to account for the cohesion of

solids and liquids; and it is the purely *hypothetical* charges that are supposed to constitute the electric current.

In no case is there any tangible evidence of the presence of these postulated charges. The atom is electrically neutral, so far as we can determine; the solid aggregate is unquestionably neutral and, except for minor and incidental effects, a conductor carrying a current is likewise neutral. In order to give the charge hypothesis any plausibility at all it is necessary to explain the observed neutral conditions by the assumption that there are equal numbers of positive and negative charges present in the atom, in the solid, and in the conductor, and that the effects of these oppositely directed charges neutralize each other, although observation of the known charges shows that when charges of opposite polarity are brought into close proximity they do not neutralize each other's effects, they destroy each other.

Furthermore, there is *additional* evidence available in each case to further strengthen the conclusion that naturally follows from the foregoing: the conclusion that the hypothetical charges are nonexistent. As pointed out in the preceding chapter, an electric current can easily be distinguished from a flow of static charges, and since the latter are known to be charged particles, this establishes a *prima facie* case in favor of the contention that the mobile units which constitute the electric current are not charged particles. The conflicts between the nuclear atom theory and established physical principles are notorious, and almost every behavior characteristic of the known electric charge must be repudiated in order to entertain the hypothesis that the atom is constructed of charged particles. The electrical theory of solid and liquid cohesion is an even more astonishing collection of contradictions and inconsistencies, many of which have been discussed earlier in this volume or in preceding volumes of this series.

On considering this situation as it now stands, without taking the historical development into account, it seems incredible that a hypothetical system so internally inconsistent and so definitely in conflict with known facts and established physical principles should be so generally accepted by the scientific community. If we ask the specific question, Do these hypothetical charges actually exist?, the answer on the basis of the evidence now available must necessarily be a resounding No! Strenuous efforts by successive generations of physicists

have produced some impressive *mathematical* correlations between theory and experiment, it is true, but, as emphasized in Chapter III, mathematical agreement is no guarantee of conceptual validity, and these mathematical successes do not in any way offset the miserable performance of the charge hypothesis from the conceptual standpoint.

Why, then, has this hypothesis achieved such virtually unanimous acceptance, not only in one, but in *all three* of these applications? Some of the items that were discussed earlier in this presentation, such as lack of recognition of the limitations of mathematical methods, failure to realize that it is the shortcomings of a theory rather than its good points that render the ultimate verdict on its validity, and the like, must take their share of the blame, but the principal reason why the negative answer to the question as to the validity of the charge hypothesis has not appeared is that the question itself has not been asked. What has happened is that the physicists have been unable to find any other force capable of producing the observed effects and consequently the electrical hypothesis has never been seriously challenged. As the physicists see the picture, the choice is between electrical, magnetic, and gravitational forces. The gravitational force is too weak, and there are a number of reasons why magnetism must be ruled out. It has seemed, therefore, that the observed phenomena must be attributed to electrical charges, notwithstanding the many indications to the contrary. Consequently, the contradictions and inconsistencies that are so common in existing theory are not currently regarded as casting any doubt upon the validity of the electrical theory *per se,* but merely as defects in the formulation of the theory which presumably will be corrected item by item as scientific knowledge advances.

The emergence of a new theoretical system in which electric charges play no part at all in any of the three phenomena discussed in the preceding paragraphs—the structure of the atom, the new theory of which was presented in Chapters VI and VII, the electric current (Chapter XI) and the cohesion of solids and liquids (Chapter IX)—now places the whole situation in an entirely different light. The question now becomes, Which of these theories, the electrical or the non-electrical, is supported by the evidence from experiment and observation? Once this question is asked and the issue is squarely faced, there can be no doubt as to the answer. There is no direct evidence indicating that electric charges take part in these

phenomena—any conclusion to that effect is merely inference or supposition based on indirect considerations—whereas there is much direct evidence to the contrary.

However reluctant the scientific profession may be to discard a theory (or more accurately, *three* separate theories, since the three applications which we have been discussing have no common denominator other than the hypothetical electric charge on which all are based) that is so far-reaching and that represents so much time and effort on the part of so many people, this theory is no longer tenable. The only real justification for retaining it after its foundations were destroyed by advances in experimental knowledge has been the lack of any alternative, and when such an alternative appears, as it now has, this justification automatically vanishes.

In beginning a survey of the principal characteristics and effects of electric charges as they exist in the theoretical RS universe, and hence, because of the demonstrated identity between the RS universe and the actual physical universe, exist in the latter as well, we note first that these charges are particularly easy to produce in the subatomic particles that rotate in only one dimension—the electron and the positron—and these particles are therefore the most familiar kind of charged objects. The association of "electron", and "charge" in scientific thought has, in fact, been so close that existing physical and chemical theory has been developed on the assumption that the common negative charge rests *solely* in the electron and that any such charge that may be observed in any other body is due to the presence of electrons within that body. Even the positive charges on atoms or atomic groups are explained on the assumption that the neutral atom or group possesses a specific number of electrons and that it is a deficiency in this number due to loss of one or more electrons that manifests itself as a positive electric charge.

The relatively recent discovery of the positron, a particle identical with the electron except in polarity, has struck a devastating blow at the foundations of this hypothesis. Physicists are understandably reluctant to recognize the havoc that this discovery has caused in their theories and they are making every effort to reconcile the positron with existing ideas in one way or another. One current hypothesis, for instance, is that this particle constitutes a "hole" in the general space-time structure. But such hypotheses as this are actually nothing more

than alternate ways of expressing the observed fact that the positron is simply the mirror image of the electron. Unless some sound theoretical basis for a distinction between the two can be produced, it is evident that the positron should have the same sort of properties as the electron, and the great differences between the two that are disclosed by observation therefore constitute an anomaly for which present-day theory has no explanation.

Prior to the discovery of the positron it had been understood that the positive counterpart of the negative charge of the observed electron was the positive charge on the "proton," an entity defined as the "nucleus" of the hydrogen atom, and there was a great deal of speculation as to the reason for the lack of symmetry between the proton and the electron, speculation which is now seen to have been meaningless, since these are actually entities of a quite different character and there is no reason why they should be symmetrical. But even though this point has been clarified, the original erroneous concept of the relation of proton to electron still survives in the nuclear theory of the atom.

The *observed* is a hydrogen atom carrying a positive electric charge equal in magnitude to the negative charge on the electron. The observations give us no indication, however, as to whether the proton is formed by the *addition* of a positive charge to the hydrogen atom or by *removal* of a negative charge from that atom. When the nuclear theory was originally formulated the only mobile charges that were known were negative, and hence the removal hypothesis was the natural one at that time. Discovery of the positron has destroyed the force of the original argument and it is now evident that the identification of the observed proton as the "nucleus" of the hydrogen atom is purely hypothetical. Development of the Reciprocal System goes a step farther and shows that this hypothesis is erroneous.

In the RS universe the electron is an uncharged particle with a displacement in space. It is capable of acquiring a rotational vibration, or charge, in time: a negative charge, as customarily designated. The positron is an uncharged particle with a displacement in time, and is therefore capable of acquiring a rotational vibration, or charge, in space: a positive charge. The atom—any material atom—is an uncharged compound system of motions with a net displacement in time, hence, like the positron, it is capable of acquiring a rotational vibration, or charge, in space: a positive charge.

The charge on the atom is a *motion of the atom,* not something that results from attachment or detachment of mobile charges. A proton is not a "hydrogen nucleus"; it is a hydrogen atom with an added vibrational motion. An alpha particle is not a "helium nucleus"; it is a helium atom with two units of charge; that is, two units of rotational vibration. A sodium ion is not a sodium atom that has lost an electron; it is a sodium atom with an added vibrational motion. *All* charges originate in exactly the same manner that the charge on the electron originates: by addition of a rotational vibration to an existing rotational motion of the opposite space-time direction.

The lack of symmetry between the properties of positive and negative charges in the material universe is not due to anything inherent in the charges, but to the nature of *matter*. Positrons are rare in the material environment because in the uncharged state they are single units of time displacement and, as such, are readily absorbed into the structure of the material atoms, whereas the ability of these atoms to utilize electrons is severely limited. Positive ions, however, are more common than negative ions, particularly if we consider the material universe as a whole, because an atom of any element can acquire a positive charge, since the net rotational displacement of any material atom is in time, but only a relatively small number of elements can form negative ions, as only a few of them have the one-dimensional rotational space displacement that is necessary for the acquisition of a negative charge.

Mechanical principles indicate that in order to produce a rotational motion, either unidirectional or vibratory, by means of linear forces, a force couple is necessary. Where the couple is provided by interaction between an electron and an atom of a solid conductor, the atom is not as readily moved as the electron and it may or may not acquire a charge, depending on the circumstances. Where the couple is provided by interaction between two atoms or small atomic groups, as in a liquid or gas, both of the interacting units are free to rotate and are approximately equal in size, hence both acquire charges. The directions of these charges are opposite, and at low ionization levels liquid or gaseous ions are therefore usually produced as *ion pairs.*

Although gaseous ions are more important in the universe as a whole—most of the gaseous matter in the stars and much of that in interstellar space is ionized—liquid ionization is a familiar feature of our

local environment, and observation of ionization and related processes in solutions has furnished the background, unfortunately an erroneous background, for a large part of present-day atomic and electrical theory. The most serious mistake that was made in the interpretation of these observations was to conclude that ionization is a process of separation of the molecule into previously existing charged components. Like the equally erroneous conclusion that charges in general are due to excess or deficiency of electrons, this was a reasonable supposition in the light of the limited amount of knowledge about ionization and related phenomena that existed at the time, but the consequences of an error are none the less serious if the error is excusable.

The key piece of information that was lacking when the basic ideas in this area were being formulated is the fact that electric charges are easily *created* and easily *destroyed*. Today the assertion that the electrons, which emanate from a disintegrating atom, were not present as such in the intact atom but were created in the process of disintegration is accepted without demur, since the creation of such particles is now commonplace. But such an idea was wholly foreign to the thinking of Faraday and his contemporaries, and they felt perfectly safe in assuming that if electrons emanate from a radioactive atom they must have been present in the original atom, and similarly that if a molecule separates into ions in solution, it must have existed as an association of such ions before solution took place. The emergence of a new physical theory now brings into focus a point which, by this time, should have been recognized in any event; that is, the advance of experimental knowledge has dealt just as harshly with the nineteenth century theory of ionization as with the nineteenth century theory of radioactive disintegration. In both cases it is now clear that the charges have no prior existence; they are created in the process.

Identification of the process of solution as the point at which the charges are created eliminates the major problems that confront existing theory. One important point is that it provides an agency, the thermal energy of the liquid, that is adequate to account for the action which takes place. As pointed out in Chapter VIII, the currently accepted electrical theory of the cohesion of matter is singularly lacking in plausible explanations for the processes which it postulates, and one of the issues on which this theory is particularly vague and confused is how the ions originate in the first place.

There has been an attempt to devise an explanation based on a hypothetical tendency for the atoms to assume a structure similar to that of the inert gases; that is, it is postulated that chlorine which, according to the electrical theory, has 17 orbital electrons, tends to gain another in order to attain the argon value 18, whereas sodium, which is presumed to contain 11 such electrons, tends to eject one in order to reach the neon value 10. This hypothesis has a ring of plausibility as long as we confine our attention to compounds of the NaCl type, but these are relatively few in number, and as soon as we turn to other kinds of compounds the theory breaks down. The hypothetical loss of two electrons from the positive components of $FeCl_2$, $CuCl_2$, or $ZnCl_2$, for instance, leaves us with 25, 27, and 28 electrons respectively, none of which is anywhere near the inert gas values 18 or 36. To get around this difficulty the theorists have executed one of the most amazing scientific maneuvers ever recorded.

In order to appreciate just what has taken place, let us bear in mind that the *basic premise* of the electrical theory, or electronic theory, as it is now more often called, because of the change in thinking that we are now discussing, is that the cohesion of solids and liquids is due to the electrostatic forces between oppositely charged components of these structures. When this basic premise is accepted it then becomes necessary to find some explanation of the origin of the charges, inasmuch as the atoms of matter, in their normal states, are not charged. The concept of gain or loss of electrons by virtue of a hypothetical tendency to attain the inert gas (or some other particularly stable) electronic pattern was invented for this purpose. It is thus what we may call an auxiliary premise, one which is not directly involved in the cohesion hypothesis, but is directed at a collateral issue raised by that hypothesis. The electronic pattern does not explain the cohesion; it merely offers an explanation of the origin of the hypothetical ions whose electrostatic attraction is assumed to account for the cohesive force.

But somewhere along the line the theorists have lost sight of their objective. They have forgotten that the electronic pattern is only a means to an end—to provide some justification for the hypothesis that a solid aggregate is composed of positively and negatively charged constituents—and they have come to look upon the electronic pattern as an end in itself. Then, since the original objective imposed some restrictions on the kind of assumptions that could be made concerning

the electronic pattern and interfered with free exercise of the imagination in fitting that pattern to the observed behavior of matter they have blithely jettisoned their original premise, and now explain most compounds by the concepts of "covalent bonds", "hydrogen bonds", etc., which provide no oppositely charged components. "It is apparent," says a textbook, "that covalence cannot properly be classified as positive or negative."113 This is equivalent to removing the first floor of a building and leaving the second floor suspended in air.

The need for any such weird procedures is automatically eliminated by the new theoretical system, which provides a single mechanism of universal applicability to account for the cohesion of all solids and liquids, and another mechanism of general applicability to account for ionization. The new system likewise provides a simple and logical explanation of the differences in the solubility characteristics of various classes of substances. According to these new findings, the distinctions that are commonly drawn between polar and non-polar substances, electrolytes and non-electrolytes, etc., are matters only of degree and have no fundamental significance. The cohesion of all solids and liquids, regardless of composition, results from exactly the same cause: the establishment of equilibrium between the inward-directed space-time force and the outward-directed rotational forces of the individual atoms. Any substances in solution may be ionized by the thermal forces of the liquid acting against the cohesive forces, providing (1) that such a substance contains both a component capable of taking a positive charge and one capable of taking a negative charge, and (2) that the bond strengths do not exceed the strength of the liquid thermal forces. Metals, for instance, cannot be ionized, as they do not comply with requirement (1): they cannot be negatively charged. Most organic compounds are nonelectrolytes because they do not comply with requirement (2): their cohesive forces are too strong (that is, their rotational forces are especially weak).

The explanation of electrolytic *processes* provided by the Reciprocal System does not differ greatly from that embodied in previous theories. The most obvious point of difference is in the identification of the moving entities. Existing theory calls for a movement of *charged electrons,* which are said to be carried by the negative ions through the solution from the location of the original ionization to the cathode and then travel independently through the external circuit to the point of neutralization at the anode. In the Reciprocal System there

is a movement of *units of space displacement* over the same path. In the solution these displacement units manifest themselves as negative charges; in matter they become uncharged electrons.

The change in aspect which the space displacement unit undergoes when it enters a new environment at the cathode warrants some special comment as it is typical of the kind of changes that are now causing the physicists so much distress: those which Marshak admits, in the statement previously quoted, are "extremely disconcerting". The situation here is that the physicists' concept of continuity or persistence in the physical universe is based largely on their observations of matter. The atom of matter is a complex structure which because of its complexity, cannot be *directly* converted into anything else. It may expel particles; it may absorb particles; it may even split into two or more smaller atoms, but it does not suddenly change from atom to non-atom (except perhaps in an annihilation process, and even this process is not commonly regarded as a conversion of the atom into something else, but rather as a destruction of the atom). With this example of the atom before them, the physicists and their colleagues in other scientific fields have formed a concept of the basic entities of the physical universe as things: units whose identity persists through the various physical processes to which they are subjected.

On the basis of this concept, the activities of the theoretical branch of physical science have been directed toward finding explanations of physical phenomena, which will preserve the identities of the "things" that are involved. Discovery of the electron and observation of the ejection of electrons by radioactive atoms led to the formulation of a theory of atomic structure in which electrons participate *as electrons.* Collateral requirements stemming from this hypothesis then led to the further conclusion that charged hydrogen atoms, or protons, also participate in the atomic structure as protons. When neutrons were discovered, the theory was modified to include these particles in the structure *as neutrons.* Now that mesons have appeared in great profusion, vigorous efforts are being made to devise means whereby these particles can participate in the theoretical structure of the atom *as mesons.* It is this concept of the persistence of electrons as electrons, of neutrons as neutrons, etc., that is now being systematically demolished by the experimenters, to the great distress of the theorists.

The truth is that the universe simply is not constructed in the manner that present-day theorists envision. Atoms, electrons, neutrons,

mesons, and the like, are not "things"; they are combinations of various kinds of motion, and they have no persistence from one environment to another, except to the limited extent that structural complexity places some restrictions on the kind of transformations that can take place–a qualification that is significant only in the case of the atom. A neutron, for example, is not absorbed by an atom *as a neutron;* it is absorbed *as a unit of time displacement,* and the neutron, as such, does not play any part in the structure of the atom. The unit of time displacement, which was the essence of the independent neutron merely, *adds to* the previously existing motion of the atom and becomes an integral part of that motion. It is the *unit of time displacement* (that is, the unit of motion) that persists, not the neutron.

The frequent transformations and exchanges of identity among the sub-atomic particles that are so bewildering to the present generation of physicists are perfectly normal processes, and the only step that is necessary in order to make them fully understandable is to discard the traditional idea that the participants in these processes are "things." Once it is realized that only the unit of motion persists and that the particular aspect, which this unit will wear, depends on its environment, the whole situation clears up automatically.

In the electrolytic process, which we are now considering, the withdrawal of electrons from the cathode by means of the external energy source (battery or equivalent) creates the electrical equivalent of a vacuum in the cathode. The negative ion cannot penetrate matter, but the negative charge on this ion is the *equivalent of an uncharged electron,* and since it is easily detached from the ion, it is forced into the electrical "vacuum" of the cathode. In the context of previous thinking, in which a charge is regarded as a "thing" and an uncharged electron is regarded as a "thing", of a totally different, even antithetical, character, the idea of such an exchange of identities is simply absurd. But when we realize that the charge of a negative ion is not a "thing" but a motion, and that an uncharged electron is an equivalent motion—one which has exactly the same magnitude and same space-time direction—it becomes understandable that the ionic charge, which cannot exist as such within the cathode, should enter the cathode as an uncharged electron.

The RS explanation of the ionization process as a whole is similarly logical and self-consistent, and it is in agreement with all of the

known facts in the area concerned; something that no other theory can claim. Furthermore, the new system provides a specific reason for everything that happens in the process, unlike current theory, which leaves several important steps unexplained. There is a specific tangible force, the force of the space-time progression, which accounts for the atomic cohesion; there is another specific tangible force, the thermal force of the liquid molecules, which causes the cohesion to be overcome and ionization to take place; there is a specific force due to the concentration of charges in the neighborhood of each electrode which accounts for the migration of the ions to the electrodes; there is an externally applied force which causes movement of electrons from cathode to anode in the external circuit there is a specific unbalance of forces, the "electron vacuum" at the cathode and the "electron pressure" at the anode, resulting from this forced movement of electrons which causes the action that takes place at each electrode. None of these forces, those previously known or those added by the new theory, is a "demon"—an *ad hoc* construction invented for the particular purpose at hand—the existence of each one can be demonstrated independently of the application in which it has here been utilized.

As brought out in Chapter XI, the uncharged electron, a rotating unit of space displacement, can move freely through matter, a time structure, but cannot move through open space, since the relation of space to space is not motion. An uncharged positron, a unit of rotational time displacement, can move freely through open space but, in general, cannot move through matter, since the relation of time to time is not motion. There are a few substances, which have enough space displacement in their atomic structures to make positron movement theoretically possible, but there is also another obstacle to such movement because a positron is vulnerable to capture by an atom and will probably be absorbed before it has gone very far. Charged electrons and positrons are neutral from the space-time standpoint, and since they contain both space and time displacement they can move freely in either space or matter. Like their uncharged counterparts, however, charged positrons are subject to capture, and they have thus far been observed only in open space. Charged electrons are common, both in space and in matter, and in their various manifestations are known as *static electricity.*

The behavior of charged electrons in matter is similar, in many respects, to that of the uncharged electrons that constitute the electric

current. In response to potential differences they move freely in good conductors, less freely in poor conductors, are restrained by insulators, etc., and in motion they have the same magnetic effects as the uncharged units. The mutual repulsion between the charges introduces some observable differences, however, and the electrostatic forces that are exerted by the charges both while they are in motion and while they are at rest distinguish charged from uncharged electrons in a clear and definite manner. The origin and characteristics of these electrostatic forces and the nature of the magnetic effects will be given some further consideration in the next chapter after the underlying principles have been clarified.

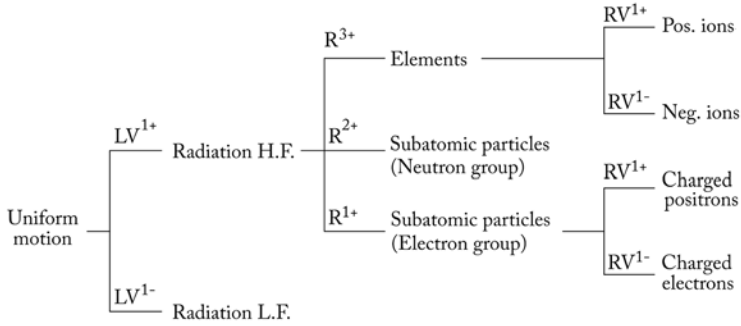


Chart C

With the additions, which have been made to the compound motion system in the subject matter of this chapter, we may now expand Chart B in the manner shown in Chart C. The explanation of the nature and origin of the charges, as indicated by their positions on the enlarged chart, and the clarification of the true relation of electric charge to electric current constitute item number eleven in the list of Outstanding Achievements of the Reciprocal System. The particular innovation that has been introduced here and has made this achievement possible should be somewhat less disturbing to existing habits of thought than most of its predecessors. The idea that a charge is a motion—a rotational vibration—is, of course, entirely new to science, but it does not conflict with any previous explanation of the nature of the charge, since no such explanation has ever been proposed heretofore, and the new concept is therefore an addition to current thought rather than a revision. Some of the consequences of the innovation are at odds with accepted ideas, to be sure, but this is always true when new concepts are introduced.

CHAPTER XIII

Into a Second Dimension

Although it may not have been apparent at the time, as soon as the compound motion principle was stated in Chapter VII and the development of the structures discussed up to that point was shown graphically on Chart A, the entire course of further development was clearly and unmistakably defined. Each additional step that we have since taken was definitely required for a logical and orderly extension of the system portrayed by the chart, and as each successive advance was made, an examination of the chart as currently revised clearly indicated what the next step must be.

Chart A was obviously incomplete at the rotational level, since we know that rotation can take place in one or two dimensions just as well as in three dimensions. Extension of the theoretical structure to include rotation in less than three dimensions then added the sub-atomic particles to the system, as indicated in Chart B. But this chart was clearly not complete either, as only three general types of motion — unidirectional translation, linear vibration, and unidirectional rotation — had been introduced up to this point, whereas a fourth — rotational vibration — was still available. Chapter XII examined the effect of addition of one-dimensional rotational vibration to the structures of Chart B and produced positive and negative ions, the charged electron, and the charged positron, as indicated on Chart C.

Now an examination of the enlarged chart shows that there is still a vacant place in the picture. Rotational vibration cannot be three-dimensional, for reasons previously explained, but two-dimensional rotational vibration is possible, and this kind of motion must therefore be added to the system. Before proceeding with this addition, however, it may be advisable to make a few comments on the general nature of the results that will be obtained from here on. Thus far, the nature and properties of the physical entities of the RS universe have not been very far out of line with currently accepted ideas as to the characteristics

of the corresponding entities of the observed physical universe, The resemblance is, indeed, reasonably close in the case of the better-known phenomena such as radiation and matter. Where the conclusions of the Reciprocal System in these areas are at variance with current doctrine, scientific literature usually contains at least a few speculations somewhat along the line of the conclusions reached herein, and the new ideas are therefore not entirely unfamiliar.

As we have moved into areas where factual information is less plentiful and where existing theory is vague and confused, the agreement between existing theory and the new theoretical structure has become progressively poorer. The new electrical theory outlined in Chapters XI and XII, for instance, calls for a wholesale revision of existing ideas and concepts. Now we are about to enter some areas in which factual information is still more scarce and in which existing theory is still vaguer and more confused. In these areas the new theoretical system will diverge still farther from existing thought. The ideas developed in this present chapter will bear little resemblance to current physical theory and those in the next chapter practically no resemblance at all.

Since this almost total lack of agreement with previous thought may be hard for many scientists to accept, it should be emphasized that such divergence is inevitable. It is in these relatively new and poorly understood regions that the weaknesses of present-day theory are so clearly exposed, and it is here that the urgent call for a "drastic change in our physical picture," a "recasting of fundamental ideas" and a "basic conceptual innovation", originates. If we are to have a drastic change *in our physical picture* then there must necessarily be some drastic changes *in our description of physical processes* in the less clearly understood areas of physical science.

In this connection, it should be realized that the lack of adequate information from observation and experiment is not the same handicap to a purely theoretical construct like the Reciprocal System as it is to the ordinary physical theory. The usual theory is designed to explain the observations, and if the observations are limited and of uncertain accuracy, the theory is correspondingly unreliable. The Reciprocal System, on the other hand, is derived entirely from the Fundamental Postulates, and the conclusions of this system are independent of any information from observational sources. It is convenient, to be sure,

to be able to check these conclusions against the results of observation at every stage of the theoretical construction as a means of keeping the chain of reasoning free from error, but in principle, this continuous checking is not necessary, and if sufficient care is taken in the logical and mathematical development the theoretical conclusions should correctly represent the physical facts not only in the areas where observational information is reasonably complete, but also in areas where it is meager and questionable, and even in areas which are as yet entirely unknown to observation. It must be conceded that where continuous checking against observation is not possible, accuracy in all details is not likely to be maintained, simply because of the limitations of human reasoning processes, but there should be no question as to the validity of the general picture derived by extension of principles whose validity has been established in the more familiar and accessible regions.

With this knowledge that we are likely to find some things considerably different from the way in which present-day physical science pictures them, let us look at an atom of matter to which has been added one or more units of two-dimensional positive rotational vibration. A one-dimensional addition of the same kind was previously identified as an electric charge and the product as a positive ion. We can expect the effect of the two-dimensional vibration to be quite similar, and it is evident that we can identify this effect with the physical phenomenon known as *magnetism*. The result of the addition of rotational vibration in this case has been the production of *magnetized matter*.

Since electric and magnetic phenomena originate in the same manner and have only one basic point of difference–the number of effective dimensions of rotational vibration–it will be appropriate to use the same terminology in application to both, and to consider the terms "electric" and "magnetic" as convenient abbreviations for the rather awkward expression "one-dimensional rotational vibratory" and its two-dimensional equivalent. Thus we will designate the two-dimensional rotational vibration as a magnetic charge.

Magnetic charges, like electric charges, can be either positive or negative, but since all two-dimensional rotation in the material universe is in time, all of the magnetic charges directly associated with matter are positive. The geometry of two-dimensional rotation is such, however, that the direction of the rotational motion relative to any external object

varies with the location of that object. A rotation, which is clockwise from one direction, is counterclockwise from the opposite direction. If the scalar space-time direction of the rotation is outward with respect to an object in the direction from which this rotation appears clockwise, it is inward with respect to an object in the other direction. A positive magnetic charge therefore has both positive and negative aspects, and the two centers of the directional effects, or *poles*, have many of the characteristics of opposite electric charges. An important difference is that a single pole does not exist by itself; there is no magnetic equivalent of the isolated electric charge. Inasmuch as the poles are merely two aspects of the same thing they always occur in pairs, and no matter how many times we may subdivide a piece of magnetized matter, each fragment has both a positive and a negative pole.

The *forces* exerted by magnetic charges are similar, in their general aspects, to those produced by electric charges, and also to gravitational forces. The magnitudes of all of these forces can be represented by the same equation:

$$F = kX_1X_2/d^2$$

where k is a constant with a specific value in each of the three phenomena, and X1 and X2 represent the two (apparently) interacting quantities: masses, magnetic charges (flux) and electric charges respectively.

The identity of the force equations is to be expected since electric and magnetic charges are rotational motions of the same general character as the gravitational rotation, differing only in that they are vibrational rather than unidirectional, and in having fewer dimensions. Since the force is a scalar effect of the motion, it is immaterial whether this motion is vibrational or unidirectional, and the only *significant* difference between the three phenomena from the force standpoint is in the dimensions of the motion.

The existence of both positive and negative electric charges and magnetic polarities of opposite directions has generally been accepted as convincing evidence that the origin and nature of electric and magnetic phenomena must be quite different from those of gravitation, which always has the same direction in our familiar everyday world. The findings of this present work are that this conclusion is wrong on two counts. First, gravitation does not always operate in the same direction, but has different directions in different regions of the

universe. One of these, the time region, in which there is motion in time within a single space unit, has already been mentioned, and other such unfamiliar regions will be discussed in Chapter XIV.

The second significant fact disclosed by the present investigation is that even in the regions where gravitation is always inward, the reversibility of magnetic and electric phenomena does not originate from any different basic characteristics; it is purely the result of dimensional differences. Obviously three-dimensional rotation does not have the kind of directional aspects that are responsible for the generation of magnetic polarities by two-dimensional rotation. Likewise, the status of matter as a compound motion with net displacement in time means that the three-dimensional motion of material atoms always has the same direction, not because rotation in the opposite direction is impossible, but because it is net rotation in the material direction that distinguishes matter from non-matter. The three-dimensional rotation *of the material atom* thus lacks the reversibility of the one-dimensional rotation, which makes it possible for electric charges to be either positive or negative.

In order to understand just how the electric and magnetic forces are related to the gravitational force, let us take a closer look at the direction of the gravitational motion. As brought out in the previous discussion, the gravitational motion of each individual atom is not a relation between this atom and other atoms of matter, as it seems to be, but a relation between the individual atom and the general framework of space-time. The scalar aspect of the rotational motion of the atom moves it inward in space toward all locations in space-time, in opposition to the motion of the space-time progression, which is carrying the location that the atom occupies (momentarily) outward in space away from all other locations. We cannot see space locations, but we can see objects, which occupy these locations, and we therefore note that each such object, if not restrained, moves inward in space toward all other objects.

It is important to realize, however, that what we see is only one part of the action that is taking place. We see a unit mass, which we will call object A, moving in *space* toward the *spatial location* occupied by object B but; in reality, object A is moving in *space-time* toward the *space-time locations* occupied by object B. The significance of this, in the present connection, is that if object A were moving, only toward the

spatial location occupied by object B. then the mass of object B should not affect the velocity of A (the gravitational force). This, of course, contradicts experience, which indicates that the force is proportional to the mass of B. The explanation is that although the m mass units of object B occupy substantially the same spatial location, they occupy m different temporal locations, and consequently m different space-time locations. What we see as a motion toward one specific space location is actually a motion toward m different space-time locations, and its magnitude is m times as great as the portion of the total motion of object A that is directed toward a single space-time location.

A reference to the somewhat analogous relation of the gravitational force (or motion) to distance may be helpful if there is any difficulty in grasping the nature of this force to mass relationship. From the probability principles we can deduce that a scalar effect such as the gravitational force is exerted equally in all directions. It follows from geometrical considerations that at distance d the total force is distributed over a spherical surface of radius d, and the portion of the total force which is exerted against a unit area at this distance depends on the ratio of that unit area to the total area of the spherical surface. This is the familiar inverse square relation. If the unit area is so small compared to the total surface that the probability of any appreciable number of coincidences in n units selected at random is negligible, the force exerted against n units is then n times the force exerted against one unit.

If we now substitute locations in space-time for locations in space, it can easily be seen that the general situation remains the same. Again the force exerted against an individual space-time unit depends on the ratio of that unit to the total number of space-time units over which the force is distributed, and since each mass unit occupies a separate unit of space-time, even though it may be part of an aggregate of m units occupying substantially the same space location, the force exerted against these m mass units is m times the force exerted against one unit.

The general characteristics of the forces exerted by electric and magnetic charges are similar to those of the gravitational forces discussed in the preceding paragraphs; that is, an object A carrying a unit charge moves toward or away from the location occupied by another charged object B. and the motion of A, or the corresponding force, is proportional to the charge on B. The explanation of this relation is the same as that given for the analogous gravitational

phenomenon. The electric and magnetic forces are, however, much stronger than the gravitational forces and this is a point that needs some further attention.

For an explanation we again turn to a consideration of the situation which exists in three-dimensional time. As already noted, the net displacement of the rotation of material atoms is in time, and when we speak of them as rotating in three dimensions, these are three dimensions of time, not dimensions of space. Time is connected with space only as a scalar quantity, and hence only one dimension of an n-dimensional motion in time can transmit its effects into space. If the motion is one-dimensional, all of the effects can be transmitted. If it is two-dimensional, the fraction transmitted into space is 1/c of the total, where c is the magnitude of unit velocity. Similarly, the transmitted fraction is only $1/c^2$ in the case of three-dimensional rotation.

The direction in space corresponding to the scalar magnitude transmitted from the time region is indeterminate and the effects of the rotation in time are therefore distributed over three dimensions of space by probability factors irrespective of the characteristics of the time rotation. But the full effect of the one-dimensional electric rotation (or rotational vibration) is experienced in space, whereas only 1/c of the effect of the magnetic rotation and only $1/c^2$ of the effect of the gravitational rotation is transmitted into space. Since c is the velocity of light, a very large quantity in the context of our world of everyday experience, the magnetic force is inherently much weaker than the electric force, and the gravitational force is much weaker still. Gravitational forces play such a significant role in the universe only because of the tremendous concentrations of matter which make the aggregate strength of these forces enormously greater than that of the electric and magnetic forces, in spite of the disparity in the size of the individual units.

In the light of the foregoing explanation the question now naturally arises as to why charges should act only on charges; that is, why the quantity terms q and q' in the electric force equation (Coulomb's Law) $F = qq'/d^2$ are limited to electrical quantities. If the charge is actually a motion of the same general nature as gravitation, it should be a motion toward *all* space-time locations, just as gravitation is, and it should therefore exert a force not only on charged objects but on all objects. The answer is that it *does* exert a force on all objects, but since

the force exerted on an uncharged *mass* is only $1/c^2$ as great as the force on an object with a charge of comparable magnitude, the effect on uncharged matter is too small to be significant. Similarly, magnetic charges (magnetized matter) not only exert forces on other magnetic charges but also exert analogous, though much smaller, forces on all matter. The familiar classification of material substances under the designations *paramagnetic* and *diamagnetic* is made on the basis of this relatively weak magnetic effect.

Inasmuch as radiation has both electric and magnetic aspects, as the term *electromagnetic radiation* implies, it has been taken for granted in current scientific thought that the effects produced by electric and magnetic charges are propagated by means of this radiation. Then, since the gravitational force bears such a close relationship to the electric and magnetic forces, it has been further assumed that the gravitational effects must be propagated in a similar manner and a great deal of effort has been devoted to a wholly unsuccessful search for evidence of "gravitational waves." The findings of this work now show that the physicists are correct in their conclusion that electric, magnetic and gravitational forces are phenomena of the same general nature and therefore behave in a similar manner, but these findings also indicate that instead of *all* of these forces being propagated in the *same* manner, as current thought assumes, *none* of them is propagated in *any* manner. Like the gravitational motion, the motion which gives rise to the electric or magnetic forces is a motion of the individual atom or particle with respect to the general structure of space-time, not an action of this unit on some other charged or uncharged object as it appears to be. And like gravitation, the electric and magnetic forces are therefore effective instantaneously; they are not propagated by radiation or by any other mechanism. Electromagnetic radiation is a phenomenon of a related but quite different character.

Another of the many instances where a relationship between phenomena has been mistaken for evidence of identity of the phenomena can be found in electromagnetism. It has been observed that electric charges in motion produce magnetic effects and that electric currents produce similar effects. Mainly on the basis of these observations, physicists have concluded (1) that electric currents are electric charges in motion, and (2) that moving electric charges are the essence of magnetism. In the words of a physics textbook, "magnetic

forces are forces associated with the motion of electric charges."[114]

Absence of the electric forces that would be expected to exist, on the basis of this hypothesis, in magnetized matter and in conductors carrying currents is a serious weakness in the hypothesis that is glossed over in current practice. The explanation currently offered is that the negative charges of the electrons are "exactly equal and opposite to the fixed positive charge" in the conductor, thus making the conductor electrically neutral. There are many contradictions and inconsistencies in such a hypothesis which current theory simply ignores. For example, the hypothesis requires the electric charges to be firmly fixed, so that they can account for the strong cohesive forces between the atoms of the conductor, and yet easily movable, so that they can account for the ready response of the current to any impressed potential. Furthermore, an "exact" equality between the negative charges of the current and the "fixed positive charge" of the atoms of the conductor is assumed in order to account for the fact that a wire carrying a current is electrostatically neutral, but then in order to account for differences in potential it is assumed that there is an "excess of electrons" in the regions of higher potential which "may be supposed to produce a sort of electron pressure within the metal."115 And above all, there is the very awkward fact, previously mentioned, that a flow of static charges, which is *known* to be a movement of charges or charged particles, has some characteristics which are quite different from those of a flow of electric current, which is *assumed* to be a movement of charges or charged particles, and it can readily be distinguished from the latter.

The confusion in the electric current situation was cleared up in Chapter XI by showing that the Reciprocal System requires the current to be a flow of *uncharged* rather than charged electrons. But this cuts the ground out from under the accepted explanation of the origin and nature of magnetism, and at this time, therefore, we will want to determine what information the new theoretical development can give us about magnetic fundamentals. As we have seen, the electric charge is a one-dimensional modification of the rotational motion of an atom or sub-atomic particle and the magnetic charge is a similar two-dimensional modification. The characteristic effects of the magnetic charge originate because the one-dimensional forces are distributed over two dimensions by the second rotation. But for this purpose it is not necessary that the

motion in the second dimension be rotational, We can see why this is true if we examine the behavior of the axes of rotation. The axis of the electric rotation of an atom is a line: a one-dimensional figure. A stationary electric charge thus has no two-dimensional rotational effects. For a magnetic charge the locus of all positions of either axis is a disk: a two-dimensional figure, and the magnetic charge has two-dimensional properties. But if we move the electric charge translationally, the locus of all positions of the axis is again a two-dimensional figure, and hence a moving electric charge has a two-dimensional distribution of forces comparable to that of a magnetic charge.

The basic rotational motions of atoms and sub-atomic particles generate only gravitational forces, as they are distributed over three time dimensions even where the motion itself takes place in less than three dimensions. In their normal states, therefore, these units have neither electric nor magnetic properties. When an atom or particle is given a rotational vibration, the *scalar* direction of this motion necessarily opposes that of one of the rotational motions but there is no requirement that the spatial and temporal directions maintain any specific relation, and the full scalar effect of one dimension of rotational vibration is therefore transmitted into space. An electrically charged unit, an ion or a charged particle, thus produces one-dimensional, or electric, effects.

Similarly, a magnetically charged unit, which has rotational vibration in two dimensions, produces two-dimensional, or magnetic, effects. If an uncharged electron or positron is given a translational motion, this again is motion in two dimensions and it produces *electromagnetism,* a magnetic effect. An uncharged atom in motion produces a similar effect, to which the term *gyromagnetism* is applied, as it has thus far been observed only in rapidly rotating objects. If a charged electron is given a translational motion, the compound motion is still only two-dimensional, and the magnetic situation is the same as if the electron were uncharged, but the electric force of the charge is also effective, hence the moving charged electron produces *both* electric and magnetic effects.

We have now gone about as far in, the discussion of ordinary magnetic phenomena as can be justified in a brief general survey of this kind, but there is another magnetic effect of a somewhat different nature, not hitherto recognized as having any connection with magnetism, which we will want to examine. In order to lay the groundwork for

an explanation of this phenomenon, let us give some consideration to the elusive particle known as the neutrino. According to the findings of the Reciprocal System, the neutrino is one of the five possible subatomic particles of the material system. This particular particle has one effective unit of positive two-dimensional rotation and one of negative one-dimensional rotation. The two oppositely directed motions neutralize each other from the scalar space-time standpoint, hence the net space-time displacement of this rotational combination is zero. With both one-dimensional and two-dimensional rotations, this particle is capable of taking either an electric or a magnetic charge but, on the basis of probability considerations, the magnetic charge takes precedence, and under appropriate conditions the neutrino acquires a one-unit positive magnetic charge. This is a unit space displacement, and since the neutrino is otherwise featureless, the charged neutrino is essentially nothing but a mobile unit of space, similar, in this respect, to the uncharged electron. Like the latter, it can move freely in matter, but is barred from motion through space, simply because the relation of space to space is not motion.

Neutrinos are produced in substantial quantities in some common physical processes and since they move freely through either space or matter when in the uncharged condition, each body in the universe is subjected to a continuous flux of neutrinos in much the same way that it is subjected to a continuous bombardment by photons of radiation. Occasionally one of these neutrinos acquires a charge in passing through matter, and when this occurs the neutrino is trapped and cannot escape. The concentration of charged neutrinos in matter therefore builds up, as the material grows older.

The difference between the situation of the charged neutrino and that of the uncharged electron should be specifically noted. While these two particles are analogous to the extent that each is a unit of space and hence can move only through matter, the uncharged electron can escape from this limitation by acquiring a charge, and a continued build-up of the concentration of these electrons also builds up forces which will ultimately become strong enough to produce the required charge, The charged neutrino, on the other hand, can escape only by losing its charge, and since here also a continued build-up of the concentration of these particles builds up forces tending to *produce* charges, the possibility of losing a charge becomes more remote as the concentration increases.

In order to appreciate the significance of this build-up it is necessary to recognize that the reciprocal relation between space and time makes any motion of a particle with reference to the atom in which it is located equivalent to an oppositely directed motion of the atom with reference to the particle. Inasmuch as these motions are equivalent, they reach equilibrium. Thus the thermal motion of the uncharged electrons is equivalent to and in equilibrium with the oppositely directed thermal motion of the atoms in which they are located. In the situation we are now considering the rotational vibration of the neutrinos is similarly equivalent to and in equilibrium with an oppositely directed rotational vibration of the atoms in which they are located. Since the charge of the neutrino is a magnetic space displacement its presence causes the atom to acquire a magnetic charge with a time displacement. This is opposite in space-time direction to the usual magnetic charge, a seemingly minor point of difference, but one which, in this case, has some far-reaching consequences.

The ordinary magnetic charge is foreign to the material environment, a two-dimensional space displacement in a structure whose very essence is a net time displacement, and it therefore plays a relatively minor role in the phenomena of the material universe. The oppositely directed charge of the same nature, on the other hand, is a motion identical with the basic two-dimensional rotation of the atom, except that it is vibratory rather than unidirectional. Consequently it adds to and, in a sense, merges with, the atomic rotation, and has the same general effect as an equivalent addition of rotational displacement.

Instead of exhibiting a behavior of a different kind, such as that which distinguishes an ion or a magnetized particle from a particle of ordinary matter, the two-dimensional charge due to the presence of the charged neutrino simply adds to the magnitudes of the normal properties of the atoms. For this reason we will not use the term "magnetic charge" in referring to this motion, but will call it a "gravitational charge." The most conspicuous effect of the gravitational charge is an increase in the mass of the atom. Because of its vibrational character each unit of this charge is only half as effective as a unit of unidirectional rotation and, for convenience, the mass due to this half unit of effective displacement has been adopted as the unit of *atomic weight*. The atomic weight of the normal atom is thus twice the atomic number Z (the number of effective notational displacement units) and

each unit of gravitational charge adds one unit of atomic weight. Since the number of units of charge which the atoms may acquire is variable, each normal atom of atomic weight 2Z is accompanied by a series of *isotopes* with isotopic weight 2Z + G.

In our local environment the various isotopes of each chemical element usually occur in fixed proportions and the average isotopic weight of the element is recognized as the atomic weight of that element. It is evident from the foregoing discussion, however, that the existing isotopic proportions are not inherent in the structure of matter itself but are results of the magnetic ionization level prevailing in the local environment. In a location where the magnetic ionization level is different, the isotopic proportions will also be different. We actually have some evidence of this locally, as some variability in atomic weights has been observed. For instance, the atomic weight of lead from various sources differs slightly.

We can deduce from the theoretical principles involved that in very young matter, where the magnetic ionization level is zero or near zero, there are no isotopes, and the atomic weight of each chemical element is its rotational value 2Z. Here all of the rotational combinations (elements and sub-atomic particles) that are possible, all the way from the electron to element, 117 are stable. In this young matter heavier elements are continually being built up from lighter ones by a process of neutron capture, and there is no destruction or degradation of an element once produced, unless the limiting atomic weight of 236 (the atomic weight of the unstable element 118) is reached.

If this matter is now transferred to a region of higher ionization level, such as the surface of the earth in its present condition, some of the atoms will acquire gravitational charges. From theoretical considerations it has been determined that at any given magnetic ionization level, the normal increase in mass due to acquisition of gravitational charges in the process of attaining equilibrium with the charges of the neutrinos varies as the square of the atomic weight of the uncharged atom. A quantitative evaluation, previously published, also reveals that at a one-unit ionization level, which is approximately the level of the local environment, the normal atomic weight increment varies from practically zero for the lowest elements to 3 for element 20, 10 for element 40, 23 for element 60, 41 for element 80, 54 for element 92, and so on. When the 54 increment is added

to the 184 atomic weight of the normal atom of element 92, the total becomes 238, which is above the 236 limit. In this local environment, therefore, element 92, uranium, and all above it are theoretically unstable and will disintegrate by ejection of mass. Some of the elements immediately below number 92 can also exceed the stability limit because of a probability distribution factor similar to that which permits evaporation at relatively low average temperatures.

This theoretical disintegration process which takes place in the RS universe can obviously be correlated with the observed phenomenon which we call *radioactivity*. On first consideration, however, there appears to be a discrepancy between the theoretical characteristics of the process and those, which are actually observed. The derivation of the theoretical disintegration clearly requires it to be an explosion: a single event initiated as soon as an aggregate reaches the stability limit and continuing until the process is complete. The observed radioactivity, on the other hand, seems to be a series of independent events occurring at random within the aggregate, and often extending over a very long period of time. The "half-life" of some of the isotopes of uranium, for instance, runs into millions or even billions of years.

In the context of present-day physics, these two descriptions are wholly irreconcilable, but in the Reciprocal System the radioactive explosion is simply the inverse of an ordinary explosion; that is, it is the same process with space and time interchanged. In an ordinary explosion, the action begins at one or more points in the aggregate and is propagated outward in space from these points at a high velocity. Each atom of the aggregate remains in its original state until the progress of the action reaches the location in space, which this atom occupies, whereupon it suddenly disintegrates. The explosion as a whole therefore takes the form of a series of individual explosions at different locations in space initiated successively by an agency propagated through space at a finite velocity. In a radioactive explosion, the action begins at one or more points in the aggregate and is propagated outward in time from these points at a high inverse velocity (that is, slowly). Each atom of the aggregate remains in its original state until the progress of the action reaches the location in time, which this atom occupies, whereupon it suddenly disintegrates. The explosion as a whole therefore takes the form of a series of individual explosions at different locations in time initiated successively by an agency propagated through time at a finite velocity. Aside from substituting time

for space, this description of the radioactive explosion is identical with the preceding description of the ordinary explosion.

To those who are steeped in the traditional ideas of physics, this explanation of radioactivity will no doubt appear as a wild flight of fancy. The conclusive answer to any such suggestion is the standard argument based on the analogy of the aerial map. Inasmuch as we have demonstrated the validity of the Reciprocal System as a whole by comparisons in many other fields where accurate comparisons are possible, and since there is no inconsistency between the known facts of radioactivity and the conclusions of the new system, there is no logical basis from which these conclusions can legitimately be challenged. The accuracy of an aerial map cannot be impeached on the ground that someone *thinks* there is a mountain where the map shows a lake, nor can the propagation of an explosion through time be denied on the similar ground that physicists have never heard of such a thing before.

Furthermore, it should be pointed out that even though the absence of any contradictory evidence is sufficient to establish the validity of the new theory of radioactivity, in view of the general proof of the Reciprocal System as a whole, in this instance we do not have to rely solely on the lack of any contradiction. The fact is that every feature of the theoretical radioactive explosion, with only one exception, can be verified by observation. The theory says that the explosion as a whole consists of a series of successive atomic explosions, and this is exactly what we observe. The theory says that the action will, in general, proceed very slowly, and that the time interval between successive explosions will vary over an extremely wide range, depending on the characteristics of the substance undergoing the explosion. We observe that this is true. The theory says that the action, once initiated, will continue to completion, just as an ordinary explosion does, and this is what we find happening. The only thing that we cannot verify in any direct manner is the theoretical conclusion that the action is propagated through time rather than through space. Here, of course, we must rely on the proof of the validity of the system as a whole.

This novel explanation of the seemingly haphazard series of events in radioactivity, number twelve in the series of Outstanding Achievements described in this volume, is only one of the many simple, but wholly time expected, answers that the Reciprocal System has provided for

problems that, according to current scientific thought, have no answers. "There are no physical laws to tell us—and there cannot be,"[116] says Bronowski, with reference to this radioactivity problem. From the point of view of wave mechanics, reports Čapek, "radioactive explosions are regarded as *contingent events* whose irreducible chance character manifests the basic indeterminacy of microphysical occurrences."[117] Whittaker is no less positive: "Thus the accurate prediction of the moment of the explosion is impossible *not only in present practice but in eternal principle,* and the statistical or probability law must be accepted as a primary law of nature, which can never be superseded by a more fundamental law of a deterministic character."[118]

But the Reciprocal System now provides the physical laws which Bronowski says cannot exist, it eliminates the element of chance which Čapek says is irreducible, and it demolishes Whittaker's "eternal principle," again demonstrating the error in the conclusion that the ultimate processes of nature are not "understandable and subject to law." Once more we find that the real difficulty is that the experimenters have outstripped the theorists and have penetrated into regions of the universe which the theorists are totally unprepared to deal with. When the horizons of *theory* are properly widened, the universe is once more seen in its true character as orderly and rational.

In their appraisal of radioactivity, present-day theorists have been unable to see any *spatial* relation between one decay event and the next, hence they have concluded that there is no relation of any kind, "and there cannot be," as Bronowski puts it. Current theory simply cannot visualize the possibility that a succession of events which is random from a spatial standpoint may be quite orderly from some other standpoint. But this is just the situation that exists in the RS universe, and therefore, by reason of the demonstrated identity between this theoretical universe and the observed physical universe, exists in the latter as well. Atoms, which are contiguous in space, may be, and usually are, widely separated in coordinate time. Conversely, atoms, which are far apart in space, may be contiguous in coordinate time. What the new theory tells us is that the radioactive explosion is propagated in coordinate time in the same manner that a gas explosion is propagated in coordinate space. The order in which the successive atoms are affected is just as systematic in radioactivity as in the gas explosion, but it is based on temporal proximity, not on spatial proximity. The

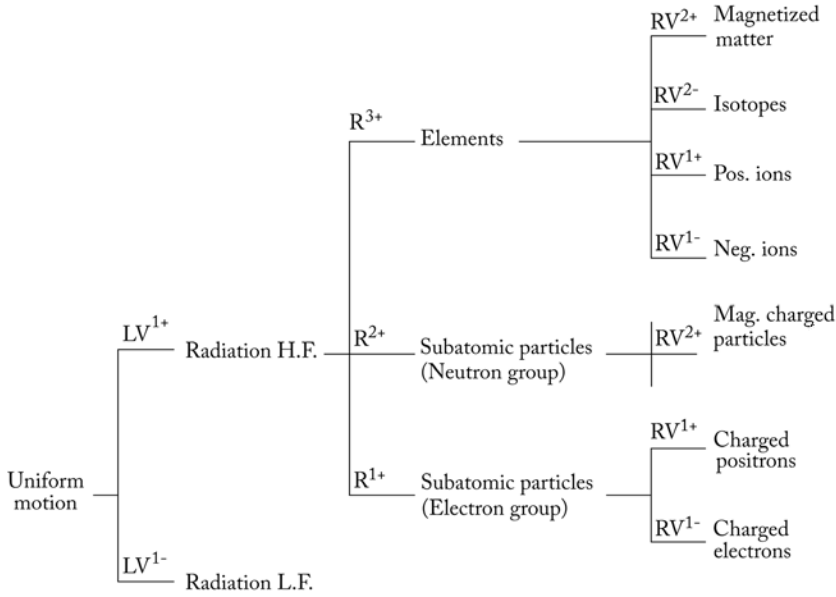
reason why the radioactive explosion takes the temporal rather than the spatial form will be explained in the next chapter.

It should be understood that this concept of an action being transmitted from one atom to another that is contiguous in time rather than in *space* has nothing to do with clock time, the only kind of time recognized prior to the development of the Reciprocal System. A gas explosion, in which the action is transmitted from one atom to another that is contiguous in space, is not affected in any way by the change in the position of these atoms due to the recession of the galaxy, the movement which is carrying it away from all other galaxies: a motion in clock space, as it has been termed in this work. This explosion is propagated in coordinate space, the extension space of our everyday experience. Similarly, the radioactive explosion is propagated in coordinate time, the hitherto unrecognized kind of time analogous to coordinate space that was discussed in Chapter VIII, and it is not affected by the position of the radioactive material in clock time, the familiar kind of time that is analogous to the clock space: the space of the galactic recession.

Although it is not generally recognized, there are two very different types of radioactivity. The one that has been discussed thus far originates when the total mass of an atom exceeds the atomic weight limit 236, and it is characterized by an ejection of mass, usually in the form of alpha particles (helium atoms). We will therefore designate this as alpha radioactivity. Another somewhat similar process occurs when the ratio of vibrational to rotational mass deviates too far from the normal value established by the prevailing magnetic ionization level. For example, the normal vibrational mass for element 40, zirconium, at unit ionization level, is 10, as previously stated. The normal isotopic weight corresponding to this ionization level is then 90. Since atoms are inherently quite stable structures, this normal isotope is not usually the only stable one, nor is it necessarily the most abundant (although in the case of zirconium it happens to be); it is the approximate center of a zone of isotopic stability, the width of which varies from element to element.

Isotopes within this zone are stable, as a rule. Zirconium has stable isotopes at 90, 91, and 92. Outside the stability zone the isotopes are generally unstable and are subject to processes, which move them toward the normal isotopic weight. Below the zone of stability the process is ejection of positrons, or some equivalent. Above the zone

of stability the movement toward the stable zone requires an action of the opposite character, and the process is ejection of electrons or the equivalent. The electrons and positrons emitted in these radioactive processes are known as beta particles, and in the present series of publications these processes will be designated as beta radioactivity. The loss of mass in alpha emission often puts the atom outside the stability zone, requiring beta radioactivity for correction of the mass ratio. The heavier radioactive elements therefore decay in a series of



steps in which alpha and beta radioactivity follow each other in a rather irregular succession.

Chart D

The addition of isotopes and the other new entities introduced earlier in the chapter, magnetically charged sub-atomic particles and magnetized matter, to Chart C completes the upper or material branch of the compound motion system, as the chart now covers all four of the basic types of motion and all of the dimensional variations that are possible for each of these types. Chart D shows how the system looks after these additions are made.

CHAPTER XIV

The Other Half

According to the theory developed from the postulates of the Reciprocal System, the destinies of the physical universe as a whole are controlled by two powerful and antagonistic forces: the force of the space-time progression, which carries all of the objects of our environment outward away from each other and tends to disperse these objects throughout space, and the force of gravitation, which moves every unit of mass inward toward all other masses, and tends to consolidate these masses into a single aggregate. Because of the dependence of the gravitational force on distance, the actual result is a compromise. Beyond the gravitational limits of the largest material aggregates the space-time progression holds sway, and the distant galaxies are receding from us and from each other with tremendous speeds. Inside the gravitational limits the gravitational forces are slowly but inexorably pulling all matter into larger and larger aggregates.

We have visible evidence of both processes. The "red shift" of the spectra of the distant galaxies enables measurement of their outward velocities. Similar observations on the globular clusters surrounding our Milky Way galaxy show that these clusters are in the process of falling into the galaxy, and we can deduce that the clusters that are observed in similar positions and similar numbers around other spiral galaxies are doing the same. As would be expected, the larger galaxies are not only capturing star clusters but also small galaxies, and we find such "satellites," in the immediate vicinity of many of the larger units. Furthermore, astronomical observations reveal that there are many galaxies which are actually in contact, which means that they are in the act of combining, and the internal structures of many other large galaxies indicate that similar combinations have taken place at some time in the past.

The course of events indicated by the RS theory, and strongly supported by observational data, is that clusters of stars—globular clusters—are formed by condensation of dust and gas somewhat

uniformly throughout space and are pulled in toward each other by gravitational forces. The rate of aggregation speeds up as the size of the aggregates increases, since a combination of two clusters has twice the pulling power of a single cluster and the volume of space within the gravitational limits increases even more rapidly. Pairs of globular clusters become small galaxies, small galaxies become large galaxies, and large galaxies become giants.

In the meantime a similar process of aggregation has been under way in the vicinity of the stars of which the clusters and the galaxies are constructed. A very substantial part of the total mass of the universe, perhaps as much as half, exists in the form of dust and gas. All diffuse material of this kind that is within the gravitational limits of the individual stars is continually being drawn in toward those stars, and that which is outside these limits will sooner or later come within the gravitational reach of some star because it is being pulled in toward the stars by the gravitational attraction of the galaxy as a whole. Current astronomical opinion tends to minimize the importance of dust and gas accretion in the life cycle of the stars, although some prominent astronomers, Fred Hoyle,[119] for example, have contended that it plays a very significant role, and G. J. Whitrow reports that "Many students of the subject believe that this (accretion) is essentially the mechanism by which all large aggregates of matter, such as galaxies, have been generated."[120]

The *theoretical* situation is very clear, and is in full agreement with Whitrow's statement. The average star in the RS universe is continually growing by reason of this accretion of dust and gas. Some of the stars in the relatively dust-free independent globular clusters and small galaxies may be merely holding their own, or even losing a little mass by reason of an excess of radiation over accretion, but the big spiral galaxies are pulling in clouds of dust and gas as well as stars and star clusters, and with so much "food" available, the stars in these galaxies are growing at a relatively rapid rate.

All this would seem to point toward an eventual condition in which all matter would be gathered into giant galaxies composed of giant stars and separated by almost infinitely great distances. The theoretical development reveals, however, that such a state can never be reached, as there are factors, which limit the size of both stars and galaxies. A full discussion of this situation is beyond the scope of this present volume, but in brief, the existence of these limits is a consequence

of increases in the magnitude of certain forces, which are directly related to the basic structure of the atom. These forces increase as the stars and galaxies grow older and larger, and they ultimately become strong enough to destroy the structures of the atoms that make up these physical aggregates. Size itself is not the crucial factor, but the limits for both stars and galaxies are related to the size.

In the star it is the build-up of thermal energy in the form of ionization and translational atomic motion that ultimately neutralizes a unit of the one-dimensional rotation of the atom and causes the catastrophic event known as a supernova, in which the star undergoes a gigantic explosion. Here the limit is reached at a particular size because the aggregate becomes hotter as it grows larger, a natural result of generating energy by processes which are roughly proportional to the cube of the diameter (the mass) and dissipating it by processes which are proportional to the square of the diameter (the surface area).

The theoretical development tells us that the larger part of the mass of a star, which becomes a supernova, is dispersed into the surrounding space by the explosion. This conclusion is quite orthodox and it is confirmed by the existence of expanding clouds of diffuse matter, which have apparently been produced by explosions of this kind. The Crab Nebula is a familiar example. But the new theory also leads to the very unorthodox conclusion that the remainder of the mass of the star is accelerated to speeds exceeding that of light and is dispersed into time rather than into space. As brought out in Chapter X, there is also ample observational evidence available to confirm this aspect of the theoretical deductions, when the observational data is taken at its face value and is freed from the illegitimate interpretations that have been placed upon it in order to force the observed facts into conformity with currently accepted ideas.

After the expansive forces have been spent, the ever-present force of gravitation reasserts itself and the material that was dispersed into space gradually pulls together to form a new star. Meanwhile, exactly the same thing is happening to the material that was dispersed into time, except that in pulling this material together, the gravitational force is reducing the amount of empty time between these particles, instead of reducing the amount of empty space between the particles as it does in the case of the matter that was dispersed outward. In each instance the contracting mass of material attains a stellar temperature before the work of gravitation is complete, and the initial product of

the process is therefore a double star in which one component is a red giant, a star in which the constituent particles are separated by a large amount of empty space, and the other is a white dwarf, a star in which the constituent particles are separated by an equally large amount of empty time. Further contraction of these stars, in space and in time respectively, ultimately eliminates the empty space and empty time and brings both stars to positions on the main sequence, which they approach from opposite directions.

While the contraction process is going on, and during residence on the main sequence after contraction is complete, each star continues accretion of material from its surroundings, and this process of growth culminates in another supernova explosion. Thus, even though the maximum size of the individual stars is limited, increasing age results in the formation of more and larger multiple star systems. In older galaxies and in the older regions of our own galaxy we can expect that there will be many systems similar, for example, to Castor, which has at least six components.

Although the foregoing description of the stellar evolutionary cycle is a purely theoretical series of conclusions derived, like all of the other conclusions of the work, entirely from a development of the consequences of the Fundamental Postulates of the Reciprocal System, there is ample opportunity to check the various features of the theoretical cycle against the results of observation. There are many gaps in the observational data, and it is not possible to check all of the theoretical deductions, but a great deal of information is available from observation and all of this information is in agreement with the theory as outlined or, at least, is not inconsistent with the theory. The new picture conflicts with other *theories*, of course. The evolutionary path of the stars in the theoretical RS universe is altogether different from that envisioned by present-day astronomers—in fact, the direction of evolution in the new system is directly opposite to that assumed in current theory—but current ideas on this score are definitely unreliable. As was pointed out in Chapter X, they rest entirely on a wholly unsupported assumption as to the source of stellar energy, and they are specifically contradicted by many items of evidence from astronomical sources. Thus, while the concept of a stellar thermal limit, the particular item with which we are concerned at the moment, is new to science, it is soundly based and well substantiated.

At this point it is again appropriate to call attention to the logical position which the new theoretical system occupies in such observationally uncertain fields as astronomy. A great deal of progress has been made in astronomy and astrophysics, particularly in the last few decades, but there are still immense vacant spaces in the accumulated body of astronomical knowledge and comparatively few of the conclusions that have been reached in this field can be regarded as anything more than tentative. Leading figures in the profession are continually warning their colleagues against placing too much trust in current theories. Harlow Shapley, for instance, emphasizes "the tentative nature of our astronomical theories" and tells us that "observation are still too scanty for confidence that our interpretations are durable."[121] W. J. Luyten similarly warns that "We must also be rather careful not to place too much confidence in our many current, but often shaky, theories."[122] The gist of these warnings is that present-day astronomical *theory* should not be mistaken for *knowledge.*

On the other hand, the conclusions of the Reciprocal System in the astronomical field are not subject to any more than that minor degree of uncertainty that applies to all human knowledge. They are direct deductions from general principles whose validity has been established in many physical fields where the facts are readily accessible and incontestable, and they do not depend in any way on the scope or accuracy of astronomical observations. Unless some error has been made in the deductive reasoning by which the detailed conclusions were reached from the pertinent general principles, the astronomical picture obtained from the Reciprocal System is therefore necessarily correct. The possibility of an error in the deductive process cannot be completely ruled out, of course, but where the chain of reasoning is short, as in this case, a serious error is not likely, and in the absence of any specific and definite conflict with observational information there is an overwhelming probability that the conclusions reached by the new system correctly represent the true physical facts. Any conflicts with currently accepted theories are wholly irrelevant in this connection in view of the admittedly uncertain and tentative nature of these theories.

A recognition of the status of the Reciprocal System as a fully integrated unit whose validity has been established in other physical fields and which is therefore independent of the current state of knowledge in the particular field to which it is being applied is more essential than ever when we turn to a consideration of the magnetic

analog of the thermal limit in the stars, the limit of magnetic ionization, not because the conflicts with existing theory are any more numerous or more serious here than elsewhere, but because in this field there are no existing theories. Neither physical nor astronomical theory even recognizes the existence of magnetic ionization, to say nothing of the relation of this ionization to atomic weight, the existence of an ionization limit, the effects of this limit, and the other related items that are discussed in this volume and its predecessors. The important point to recognize here is that regardless of the present state of observational knowledge, the section of the new theoretical structure which is applicable to these particular phenomena participates in the proof of the validity of the system as a whole. When we have established the accuracy of our aerial map by checking it against the known facts in the areas that are accessible, we then know that the map gives us a true picture in any sub-area that may happen to be inaccessible. The same is true of the Reciprocal System. Like the aerial map, this system can be tested as a complete unit, and when we have established its accuracy as a whole, we have also established its accuracy in each separate area, regardless of whether or not we are able to verify the conclusions in all areas individually.

We have already seen, in the preceding chapter, how the magnetic ionization level builds up as the age of matter increases. This build-up cannot continue indefinitely, however, as the ionization adds mass to the atom, and the total mass that an atom can have is limited. The reasons for this limitation are too involved for discussion in this general survey, but such a discussion is hardly necessary for present purposes since the existence of such a limit is an observed fact. Beyond uranium, the last of the elements which occur naturally on the earth's surface, the artificial production of new elements is meeting increasingly greater difficulties as each additional step is taken and it is evident that a limit is being approached. When the oldest material in a galaxy, which will normally be concentrated near the galactic center, reaches this limit, this matter will disintegrate in a manner similar to that in which part of the matter of a star disintegrates when it reaches the thermal limit. Since a large amount of nearby matter is close to the limit when the first such disintegrations occur, the surrounding material is brought up to the limit by the ejections from the first explosion and once initiated, the explosion ultimately involves all or most of the galaxy.

In order to clarify the nature and results of the kind of an explosion that takes place here, it is advisable to consider the relations between the several major regions of the universe in more detail. These regions are shown graphically, in a linear sequence, in Figure 3. At one end we have the *time region,* in which n units of time are associated with one unit of space, and hence all motion is in time. Next is the *time-space region,* in which n units of time are associated with m (a smaller number) units of space. Then comes the *space-time region,* in which n units of space are associated with m units of time, and finally the *space region,* in which n units of space are associated with one unit of time.

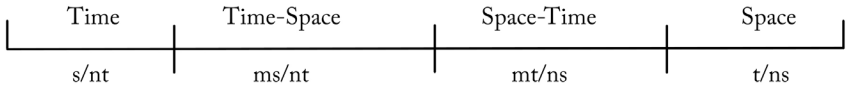


Figure 3

The ratio of space to time in this diagram increases from left to right. At the extreme left time is infinite, space is unity, and velocity is zero. At the borderline between the time and time-space regions time has decreased to unity, space remaining constant, and velocity is therefore unity *in one dimension.* As we continue toward the right through the time-space region, the amount of space increases in the other dimensions, and at the center of the diagram the velocity is unity in all three dimensions. The right half of the diagram is a duplicate of the left half in inverse order, beginning with unit reciprocal velocity, passing through the space-time region, where time decreases until at the region boundary it is only sufficient to attain unit reciprocal velocity in one dimension, and then through the space region to the extreme right where time is unity, space is infinite, and reciprocal velocity is zero.

In the time-space region, the region of our everyday experience, the progression of space is outward (toward infinity) and since outward in space is equivalent to inward in time, the equivalent progression of time is inward. In the space-time region these directions are, of course, reversed. A similar reversal takes place at the boundary of the time region. Beyond this boundary space remains constant and only time increases. This is equivalent to a decrease in space. An increase in space in the space region, with time remaining constant, is likewise equivalent to a decrease in time.

The progression does not actually undergo a change in direction. It originates anew at every space-time unit, and the directions in which

it originates are different in the individual regions. Gravitation must follow suit, as it is inherently a motion in opposition to the progression. But this fixed relation to the progression is not shared by independent motions. If an object enters the time region with an inward motion in space which it acquired in the time-space region, it still continues with the *equivalent* of an inward motion in space here where actual space motion is not possible; that is, it moves outward in time.

With the benefit of the foregoing explanation we are now able to analyze the effects of the two types of astronomical explosions. The explosion of the star is due to reaching the lower limit of matter: the destructive limit in one dimension. Here the increase of thermal motion and positive ionization, both of which are space displacements, forces the net time displacement down to zero. This is the boundary between the time region and the time-space region of our everyday experience. When the ensuing explosion occurs, part of the material of the star is ejected *forward* into the time-space region to form the familiar outward expanding cloud of dust and gas, and part is ejected *backward* into the time region. This later material expands outward into time, but since all of this time motion takes place in the same units of space in which it originates, the matter remains localized in space, and it ultimately regains stellar status as a white dwarf star.

The magnetic ionization, on the other hand, adds to the net time displacement rather than decreasing it. This ionization therefore pushes the net total displacement up to the *upper* limit of matter. When the explosion occurs and a substantial part of the mass of the galaxy is transformed into kinetic energy, the ejected material is at a space-time level near the boundary between the time-space region and the space-time region. If the amount of matter involved is relatively small, as in the case of terrestrial radioactivity, the products attain very high velocities but remain in the time-space region. In the galactic explosion, where a tremendous amount of matter is involved, the velocities are much greater and, as in the case of the supernova explosion, the ejected material is distributed to both sides of the boundary. That which is ejected backward into the timespace region moves outward in space and manifests itself as a visible cloud of particles, such as the jets issuing from the central regions of M 87 and a number of other galaxies. That which is ejected forward into the space-time region similarly moves outward in time. But unlike the time region, into which the products of the super nova explosion

are dispersed, the space-time region is not localized in space, and the high-velocity products of the galactic explosion therefore pass completely out of our material universe.

Now let us ask, What becomes of this material? It may seem a rather nebulous undertaking to attempt to follow the purely theoretical products of a theoretical process into an observationally inaccessible region, but the Reciprocal System recognizes no limits other than the limits of the physical universe itself. However inaccessible the space-time region may be to observation, it is just as accessible to theoretical development as the region in which the familiar phenomena of our experience are located.

The reciprocal principle tells us that for every entity and every phenomenon of our material universe there is another, which is identical in every respect except that space and time are interchanged. All of the features of our material universe belong on the left side of Figure 3 in the time region and the time-space region. The corresponding regions on the opposite side of the centerline contain exactly the same features in reverse. What we call the material universe is therefore only half of the total; it is one *sector* of the universe as a whole. There is another half, which we will call the *cosmic sector,* that is the mirror image of the material sector.

There may be some question as to why an adjective like "cosmic" was selected to designate the phenomena of the second half of the universe rather than "non-material," which is a seemingly obvious choice since present usage practically forces us to call our familiar half the "material" sector. It appears likely that the use of the term non-material" would lead to confusion, as some of the entities normally considered non-material are definitely part of the material sector of the universe as herein defined. The neutrino is a good example. There is also an element of convenience in using a special adjectives such as "cosmic" inasmuch as we will be able to identify the phenomena of the cosmic sector, very few of which have names of their own, by the names of the corresponding phenomena of the material sector with the addition of the word "cosmic." Thus the analog of matter in the cosmic sector will be known as cosmic matter, abbreviated c-matter. Use of the expression "non-material matter", on the other hand, would be rather awkward.

With this understanding of the general situation in the cosmic sector of the universe, let us now return to the material, which was

hurled across the boundary into this sector by the galactic explosion. The structures of which this material is composed are entirely foreign to their new environment and hence they are very subject to change. To illustrate the kind of a situation that exists here we may consider the status of a small mass of high temperature gas released into a low temperature environment. A high temperature is not inherently any less probable than a low temperature, but it is less probable in a low temperature environment, and hence this gas immediately begins to lose heat and to move toward thermal conformity with its surroundings. The material atoms are compound motions and they do not respond to changes in environment as readily as the simple thermal motion, but the same principles apply, and when these atoms arrive in the cosmic environment they immediately begin losing or gaining motions of such a nature as to bring them into harmony with their surroundings. This means, in short, that they are quickly converted into structures of the cosmic type. Such conversion is always possible because all physical structures, both material and cosmic, are composed entirely of units of space and units of time, and as long as enough units are available there is always a process or combination of processes by which any structure can be converted into any other structure. As a result of the entry of the material explosion products, therefore, a quantity of new cosmic matter is formed in the cosmic sector.

This cosmic matter is the inverse of the corresponding feature of the material sector of the universe. Corresponding to the atoms of ordinary matter, which are linear vibratory space displacements rotating with displacement in time, there are cosmic atoms, which are linear vibratory time displacements rotating with displacement in space. As there are material sub-atomic particles, similar to the material atoms except that they have effective rotational displacement in only one or two dimensions, so there are cosmic sub-atomic particles that bear the same relation to the cosmic atoms. And just as the addition of rotational vibration to the material atoms and particles generates material isotopes, ions, and other charged particles, so similar additions to the cosmic atoms and particles generate cosmic

The new c-matter is widely dispersed initially, but the cosmic atoms are subject to mutual gravitational forces and to the gravitational attraction of previously existing aggregates of c-matter. Both of these operate to draw the particles closer together in time, as gravitation in the space-time region is directed inward in time rather than inward in

space. The particles of c-matter thus ultimately condense into cosmic stars, the stars gather in clusters, the clusters combine into cosmic galaxies, and the galaxies grow into larger galaxies. In the meantime the cosmic stars of which the galaxies are composed have been reaching the thermal limit and exploding, producing increasingly large multiple star systems, and the cosmic magnetic ionization in the central regions of the older galaxies has been steadily rising. Finally a giant old cosmic galaxy, a cosmic replica of M87, reaches the magnetic limit, explodes, and hurls the greater part of its substance across the boundary line into the time-space region.

The theoretical discovery of this second half of the physical universe, a finding which, in one stroke, doubles the size of the already vast cosmos, is unquestionably one of the Outstanding Achievements of the present work, and it will be number thirteen on our list. Here again it should be remembered that this is not a wild speculation or an ad hoc postulate; it is a necessary and unavoidable consequence of the Fundamental Postulates of the Reciprocal System, and it participates in the proof of the validity of that system as a whole. Since the system is valid in general, it is valid in every part, because it is a single integral unit, not, like present-day physical science, a collection of individual theories.

One of the important consequences of the new findings is that they provide a definite answer to the hotly debated question as to whether the universe is evolving or whether it is in a "steady state." The conclusion of the new system is clear and unequivocal. The expansion of the material galaxies carries all of the matter in the universe outward toward infinite space. But no galaxy can continue moving outward indefinitely. There is a limit to its age, and hence to its outward travel. When this limit is reached the galaxy is destroyed, and the matter of which it was composed has to begin anew in the opposite sector. Here it will ultimately become a part of a system of cosmic galaxies, equal in all respects to the material system, but expanding in time rather than in space and thus carrying all of its constituent units outward toward infinite time, which is equivalent to zero space. Here again there is a limit, and when a cosmic galaxy reaches this limit it, too, is destroyed, and the material of the galaxy is transferred back to the opposite sector to start the process all over again. The movement inward toward zero space in one sector cancels all that was accomplished by the movement toward infinite space in

the other sector. Thus the universe is always changing, yet always remains the same. It is in a steady state.

Existing ideas as to the nature of this steady state must, however, be modified substantially. There are two major objections to the steady state hypothesis in the form in which it has been presented by its principal advocates, the Cambridge group of astronomers. First, it violates the conservation principles by postulating the continual creation of matter ex nihilo (out of nothing).Second, it is internally inconsistent, inasmuch as the oldest galaxies are continually growing older and larger, which contradicts the principle that the universe always looks the same from any point in time: an essential feature of the postulated steady state. Hoyle attempts to explain this contradiction on the basis that the older galaxies disappear "over the time horizon" because of the recession phenomenon, and consequently the age of the oldest galaxy within observational range will always remain essentially the same.[123] But this explanation is satisfactory only up to the time that our own galaxy becomes the oldest one within observational range. Beyond that time the age of the oldest galaxy in this region of space continually increases, which is directly contrary to the basic hypothesis.

The Reciprocal System disposes of both of these objections simultaneously, as it sets a limit on the age and size of the galaxies, and in so doing it replaces continuous creation of matter with a cyclic process in which the matter from which new galaxies are formed is derived indirectly from the disintegration of the galaxies that reach the end of their life spans. As explained earlier, the matter propelled into the cosmic sector by the violent explosions of the oldest material galaxies is converted into cosmic matter and becomes the raw material from which new physical structures are formed in the cosmic environment. The explosions of the mature cosmic galaxies maintain the equilibrium between the two sectors by ejecting an equivalent quantity of cosmic matter back into the material sector. Here the same kind of a process takes place. The cosmic matter is quickly converted to ordinary matter and it then constitutes the raw material from which new physical structures are constantly being formed in the local environment to maintain the steady state. In the next chapter some of the details of the conversion process will be examined.

CHAPTER XV

Cosmic Visitors

It is apparent, both from the discussion of the cosmic sector of the universe in Chapter XIV and from the nature of the material branch of the compound motion system, that the cosmic branch of this system is an exact duplicate of the material branch, except that all directions are reversed. It might therefore seem quite logical to complete Chart D by adding a lower branch identical with the upper branch that we have traced out step by step in the preceding chapters. It should be recognized, however, that Chart D is a picture of the material system *as it appears from within that system,* and if a lower branch were to be added, utilizing the same terminology, this would be a picture of the cosmic system *as it would appear from within the cosmic system.*

No exception could be taken to such a picture from the standpoint of accuracy. Indeed, this may ultimately be the best mode of presentation. But for the moment it is quite meaningless here in the material system as any cosmic entities which may exist in the material environment have properties in this environment that are quite unlike those of their material counterparts. Cosmic matter, for instance, as we encounter it, does not even remotely resemble the matter with which we are familiar, and it is currently treated (not very successfully) as a totally different kind of an entity and under a different name. In expanding Chart D to include the cosmic system of motions it therefore seems advisable, at least in this initial presentation, to adapt the terminology to the existing situation in the material sector. Of course, the general outline of the chart is not subject to modification, and the symbols for the various types of motion will appear just as if the chart were being prepared on the cosmic basis, but the entities that have previously been identified and named will be shown on the enlarged chart under the names that have been given to them on the basis of the prevailing impression that they are indigenous to the local environment rather than fleeting visitors from a foreign sector of the universe.

The general situation is quite clear. On the one hand we have a theoretical system which asserts the existence, somewhere in the universe, of a vast number of physical entities related to but quite different from the familiar phenomena of our local environment, and further asserts the existence of processes whereby substantial quantities of these strange physical entities are injected into our environment. On the other hand, we have recently become aware of the presence of some extraordinary physical entities in our midst, the varieties of which are already so numerous that they are extremely embarrassing for the theorists who are trying to account for them, and the behavior of which is so unusual that "strangeness" has actually been treated as a definite physical property, subject to conservation laws, etc. Obviously we can equate the theoretical and observed phenomena, and our problem then becomes one of placing each of these foreign entities in its proper place in the theoretical picture.

As brought out in Chapter XIV, relatively large quantities of cosmic matter are injected into the material sector of the universe by the velocities generated in the explosions of the mature cosmic galaxies. It was also pointed out in that chapter, however, that the ordinary matter which is propelled into the cosmic sector of the universe by similar explosions of the giant old material galaxies exists as such only very briefly after its arrival in the new sector, because the system of motions that constitutes the atoms of matter must come to equilibrium with its new environment, and this requires a conversion of the material type of motion into motion of the cosmic type. The same is true in reverse and the life of cosmic matter as such is therefore extremely short after it enters the material environment. Nevertheless, it persists long enough to be recognized by various effects, which it produces.

From the nature of the process through which it enters the material environment, and with the benefit of the discussion of the inverse process, the entry of matter into the cosmic sector, we can easily deduce what the general characteristics of cosmic matter in the local environment will be. Let us ask, then, Is there any evidence of the presence of such entities: widely dispersed individual particles, originating from some source which cannot be clearly identified, appearing approximately uniformly throughout space and throughout time, and without preferential direction, traveling with extremely high velocities, in the neighborhood of the velocity of light, and decaying into some other type of particle within an almost incredibly short

time? The answer is, Yes; we do observe entities of this kind. All of these characteristics, those which the cosmic matter ejected from the exploding cosmic galaxy should theoretically possess when it enters time material sector, are exactly the characteristics of the *cosmic rays.*

Identification of the primary cosmic rays as atoms of cosmic matter is, of course, in conflict with current scientific opinion, which regards these primaries as material atoms. It should be recognized, however, that reliable information concerning the primary rays is extremely difficult to obtain, and their identification as material elements rests mainly on a process of elimination which seemingly leaves these material elements as the only *known* type of particle that could meet the requirements. Electrons, positrons and photons are ruled out by experimental results that require an entity of a different type. Neutrinos are not capable of producing the observed results of cosmic ray interactions. Mesons and neutrons are eliminated from consideration because observations show that their life span is very short, and hence it is presumed that they must have been produced in the immediate vicinity of the locations in which they are detected. This apparently leaves the material elements as the only remaining possibilities, and the presence of multiple charged particles in the cosmic rays in proportions which conform roughly to the proportions in which the heavier material elements occur in observed structures seemingly makes the case conclusive.

The assertion of the Reciprocal System that these are cosmic elements rather than material elements now introduces a new factor into the situation. Elimination of all of the particles heretofore known, other than the atoms of matter, does not eliminate the possibility that the cosmic rays may consist of some new kind of particles, as the present work contends. The available observational methods cannot settle this issue, as they are not capable of distinguishing between cosmic atoms and material atoms at these extremely high velocities. The presence of a multiply charged particle, for instance could equally well indicate the presence of one of the higher cosmic elements as that of a heavy material element. Furthermore, there is some definite evidence indicating that the primaries are not material atoms. If we compare the reactions initiated by the cosmic rays with the results produced by fast-moving material particles in the accelerators, we find some striking differences, such as the great disparity in the production of K-mesons. The natural inference from this is that the cosmic rays are

not fast-moving material particles. There is also evidence that some of the primary rays decay in flight. For example, it is often found that one of the particles leaving the site of the first physical event initiated by the primary is a pi meson which continues in the same direction as the primary and contains the bulk of the original energy. Since there is no reason to expect material atoms of low atomic weight to decay spontaneously or to decay to pi mesons, this is a further indication that the primaries are not material atoms.

The cosmic atoms, on the other hand, have just the properties that are necessary to explain the experimental findings. They are not material atoms, hence they do not have to behave in the manner of material atoms. They are stable in their own sector of the universe and they enter the local scene directly from that sector, not from some distant part of the material sector, so that stability in the material environment is not necessary in order to explain their presence. They become unstable when they arrive, and consequently it is quite in order for one of them to decay in flight if it avoids a collision long enough.

Strong support is also given to the cosmic atom explanation by analyses of the composition of the incoming rays. Current thought regards these rays as having originated somewhere within the observable universe. Just *how* they are produced and how they have acquired their fantastically high energies are still open questions and, as Sandage recently observed, constitute one of the "major unsolved problems in astrophysics."[109] But in any event, if the rays are ordinary matter that has been accelerated to these high velocities by some unknown physical agency, as is now believed, their composition ought to be approximately that of average matter; that is, the proportions of the different elements in the primary rays ought to agree with the proportions found in the observation of material structures. The range of observed values is indicated by a recent study which found the percentage of elements above helium varying from 0.3 in the globular clusters to 4.0 in the extreme Population I stars and interstellar dust in the solar neighborhood.[124] In order to agree with current theory the percentage of elements above helium should be somewhere in the middle of this range, and certainly not above 4.0 in any case.

The Reciprocal System tells us that the composition of the primary rays should not be that of average matter, but that of very old matter much older than the oldest matter within observational range. The

proportion of heavy elements in matter increases with age (This is true with reference to the matter itself, regardless of whether the presence of old matter in a star is taken as a sign of stellar age as the Reciprocal System pictures it, or as a sign of stellar youth, in accordance with current astronomical thought) and in the oldest matter in the material universe, such as that in the stars of the central region of M87, for example, it should be well above 4.0 percent. The percentage of heavy cosmic elements in the cosmic rays should be essentially the same as the percentage of heavy elements in this very old matter of the material sector, since here again it is the galaxies that have reached the end of the current phase of the cycle that explode. This gives us a crucial test. If present-day theory s correct, the heavy element percentage should be below 4.0. If the Reciprocal System is correct, it should be substantially above 4.0. The verdict is clear and unmistakable. The percentage is well above 4.0. A review by C. J. Waddington reports that the elements above helium contribute 15.8 percent of the mass of the primary rays.[125] Even after making allowances for whatever differences may exist in the manner of compiling and expressing these results, it is evident that the heavy element content of the cosmic rays is much above that of ordinary matter.

Thus, although the amount of information that is available concerning the primary cosmic rays is very limited, it nevertheless yields strong evidence in support of the theoretical conclusion that these rays are atoms of cosmic matter. It is also highly significant that the most extraordinary characteristics of the rays, those that present-day science has found so difficult to account for, are simple and obvious consequences of the status of these rays as cosmic atoms. Recent observational results have emphasized more than ever the extreme isotropy of the cosmic radiation and the almost incredible energy of the most energetic particles. Explanation of these properties in terms of known processes is a formidable task, and the attempts that have thus far been made in this direction are highly strained and inherently implausible. But these are the *normal* and most obvious properties of the incoming cosmic matter. Cosmic atoms entering the local environment *must* have initial velocities in the neighborhood of the velocity of light, since they originate in a region where all velocities are *greater* than unity (the velocity of light), and inasmuch as they enter from a region which is not localized in space, their distribution on arrival is determined by probability, and hence it *must* be isotropic.

A still more impressive confirmation of the validity of the identification of the cosmic rays as cosmic matter is furnished by the manner in which the cosmic ray decay processes and their products agree with the theoretical events in the RS universe Our next undertaking will be to examine the theoretical and experimental aspects of these processes.

Where the only difference between a new arrival and the local environment is in the magnitude of certain properties, as in the case of the high temperature gas cited in Chapter XIV, the process of adjustment to the environment is simply a matter of giving up some of the excess motion. The problem for the cosmic atom is more complicated, as some of the components of its motion differ from those of the material atoms not only in magnitude but also in direction, but those components that are compatible with the material system can come to an equilibrium with the local environment by the simple and rapid method of direct transfer. The first effect to which the cosmic element should theoretically be subject is therefore a sort of stripping action, whereby the excess amounts of these compatible components, the translational velocity, the electric charge, and the one-dimensional rotational displacement are ejected or transferred by contact. The product of this stripping process is a member of the series of cosmic elements, which has no effective one-dimensional rotation, the cosmic equivalent of the inert gas series, with a greatly reduced velocity and only a minimum charge.

In some of the recent cosmic ray work a distinction has been drawn between the *original* rays and the *primary* rays, the latter getting defined as the first which come under observation.[126] The theoretical development confirms the validity of this differentiation. The original rays clearly must consist principally of c-hydrogen, and the product of the first stripping action will therefore be c-helium. The primary rays should thus consist mainly of c-helium. It should be noted in this connection that the cosmic atoms may *lose* part of their initial charge, but they are not likely to *gain* additional units of charge in the local environment, and a c-helium atom produced from c-hydrogen will have only one unit of charge, not two. The single charge of most of the primary particles is therefore consistent with the foregoing conclusions.

In order to complete the conversion from cosmic to material status the cosmic atom must undergo a more complex process that will ultimately reverse the direction of each of those components of the compound motion that give the atom its cosmic character. In the cosmic

elements, including c-helium, the atomic rotation has a displacement in space, whereas the basic vibration has a time displacement. To convert c-helium into some unit or units of the material system it is necessary to exchange these displacements, so that we come out with a rotational time displacement and a vibrational space displacement. The linear vibration presents no particular problem, but it is difficult, if not impossible, for a *multiple* rotational displacement to convert directly from one status to the other. Before the actual interchange can occur, it is necessary that the atomic rotation be reduced to the equivalent of a single unit; that is, to the equivalent of a neutron, the sub-atomic member of the inert gas series.

It is not feasible to cover the subject of atomic rotation in detail in a general survey of this kind, and for present purposes it will merely be stated that the theoretical investigations show that any atomic rotation with displacement n is equivalent to a rotation in the opposite space-time direction with displacement k-n, where k is a limiting value that depends on the dimensions of the rotation. By reason of this relation, the ascending series of inert gas elements beginning with the sub-atomic neutron is equivalent to a descending series of cosmic inert gas elements, in which the equivalent of the neutron is c-krypton. In order to make the transition to the material system the c-helium of the primary cosmic rays must be built up into c-krypton.

At first glance it may seem contradictory to initiate a process of breaking down an atom into simpler units by building it up to a more complex structure, but it should be recognized that in order to build up to a higher cosmic level a cosmic element must either add space displacement or eject time displacement, which is exactly what a material structure does when it breaks down or disintegrates. The cosmic building-up process is thus a breaking-down process when we look at it from the material standpoint.

The transformation from c-helium to c-krypton is accomplished by the successive ejection of units of two-dimensional rotational displacement; that is, the equivalent of neutrons. In the local environment, at least, the one-dimensional and two-dimensional particles of near zero mass, the positron and the neutrino, which are jointly equivalent to the neutron, are more easily produced than the neutron itself, and the successive decay events therefore consist of ejections of pairs of neutrinos and positrons. Two such ejections are required to take the c-element from one inert gas position to the next

and hence the decay products include not only the cosmic inert gases between c-helium and c-krypton but also the c-elements midway between these inert gas elements.

The cosmic atoms, which enter the material sector, are thereafter subject to all of the various influences that affect the material atoms in the local environment, and the details of the decay process are modified accordingly. The first decay products, for instance, are outside the zone of stability in a region of unit ionization level, because the material elements to which they are equivalent are outside the stability zone in their normal states, and these decay products are therefore radioactive. When the radioactive instability is compounded with the inherent environmental instability of cosmic elements in general, the lifetime of the normal c-atoms is reduced to the vicinity of zero and the decay of these radioactive c-particles is essentially instantaneous. Where conditions are favorable for the production of the + 1 isotopes these first products appear briefly; otherwise, the initial decay product is the first c-element in the normal decay path that is within the zone of stability, c-silicon.

The principal identifying characteristic of a cosmic ray decay particle is its mass. From the reciprocal relation it is evident that the normal mass of a c-element with cosmic atomic number n is $1/n$ on the natural scale or $2/n$ on the atomic weight scale. For convenience the masses of the decay particles are usually expressed in terms of electron masses, and using the theoretical value of the latter, the normal mass of a cosmic element of atomic number n is $3646/n$ electron masses. The theoretical mass of the first slightly stable decay product, c-silicon, is therefore $1/14$ natural units or 260 electron masses. This we can identify as the particle known as the pi meson, which has a mass usually reported somewhere in the range from 260 to 270 and is the first detected product in most cosmic ray events.

Cosmic silicon, the pi meson, theoretically decays to c-argon, which has a mass of $1/18$ natural units or 203 electron masses. This we can; identify as the mu meson, the most common and longest lived of the decay products, which has a reported mass of about 206 and is produced by decay of the pi meson, as the theory requires. The next element in the regular order would be c-cobalt, with a mass of 135, but for some reason, probably because it is within one-half of a magnetic unit of the final conversion level, this particle has an abnormally short life, and the

observed decay of the mu meson (c-argon) is a double process in which two positrons are emitted and c-krypton is produced. This c-element, on reversing the directions of its motions, becomes a neutron, or combination of neutrino and positron, and at this point the original cosmic atom has been completely converted to material particles.

If the + 1 isotopes of the early decay products are formed, the added mass due to the gravitational charge is the same as if the c-atom were a material atom; that is, a one-unit charge adds one atomic weight unit (½ mass unit or 1823 electron masses). Also we find that, for some reason, which is not yet, clear, the transformation of c-helium to c-carbon does not occur readily, and instead of following this path, the decay proceeds by way of one of the adjoining c-elements, c-boron or c-nitrogen. In either case a decay to c-neon follows. Under conditions favorable for the production of the + 1 isotopes, therefore, the complete decay scheme in the terrestrial environment is as follows:

Element	*Mass*	*Mass Increment*	*Total Mass Electron Eq.*	*Meson*	*Decays to*
c-helium	½	0	1823	primary	c-B or C-N
c-boron	⅕	½	2552	ξ (xi)	c-Ne
c-nitrogen	⅐	½	2344	σ (sigma)	c-Ne
c-neon	1/10	½	2188	λ (lambda)	c-Si
c-silicon	1/14	0	250	π (pi)	c-A
c-argon	1/18	0	203	μ (mu)	c-Kr
c-krypton	converts to neutron or equivalent				

As indicated in the tabulation, the + 1 isotopes of the lower cosmic elements in the decay path can be identified as the "hyperons" or heavy mesons that are reported by the experimenters.

In addition to the mesons produced by cosmic ray decay or by various processes in the particle accelerators, a number of so-called "antiparticles" also make their appearance in the same events. Core relation of the experimental findings concerning these particles with the corresponding theory is complicated by the fact that the reported results are in most cases inferences rather than direct observations and the nature of these inferences depends to a considerable degree on the theoretical viewpoint adopted by the experimenters. In many cases the new basic concepts developed in this work lead to altogether different

interpretations of the observed facts. The following discussion of these particles will therefore be confined to the theoretical picture as it exists in the RS universe without regard to current interpretations of the experimental findings other than to say that there are no actual experimental results, as distinguished from interpretations of these results, that are in conflict with the theoretical conclusions based on the postulates of the Reciprocal System.

Recognition of these particles is based primarily on the annihilation process in which the rotations of two oppositely oriented particles cancel each other and an equivalent amount of energy in the form of radiation is released. Two of the sub-atomic particles of the material system, the electron and the positron, are antiparticles on this basis, since the effective rotational displacements of these two particles are equal in magnitude and opposite in direction. As might be expected, the combination of the electron and the positron was the first annihilation process that was detected. No other pair of antiparticles exists in the material system, but there is a similar pair in the cosmic system, and each material atom or sub-atomic particle is the antiparticle of the corresponding structure of the cosmic system. Direct combination of complex structures such as the atoms is not feasible from a practical standpoint, and the annihilation reactions are there fore limited to the sub-atomic particles, with the possible exception of hydrogen. Anti-mesons in the usual sense (that is, particles with properties in the local environment similar to those of the mesons, but oppositely directed) are, of course, impossible, as the antiparticles of the mesons are material elements. The inferential identification of anti-mesons in some of the current reports from the experimenters cannot be taken seriously.

It should be noted that in the RS universe, the antiparticle is the inverse of the corresponding particle, not the negative. It is true that the units of space and time which enter into the construction of these particles are oppositely directed from the scalar stand point, and each is therefore the negative of the other, in a sense, as well as the inverse, but when these units are associated as a particular type of motion the "anti" form corresponding to velocity $^{s}/_{t}$ is not $^{-s}/_{t}$ but $^{t}/_{s}$. The properties of cosmic matter as defined by the Reciprocal System are thus considerably different from those of the "anti-matter" which has been the subject of so much speculation in recent years. Negative mass, for instance, is not possible. If the mass of a material atom is m, the mass of the corresponding cosmic atom is not -m but $^{1}/_{m}$, which is still a positive quantity.

The possibility that some of the observed galaxies may be composed of anti-matter or that the juxtaposition of matter and antimatter may be responsible for the strong radio emission and other peculiarities of certain galaxies is also ruled out. The new theoretical system confirms the existence of cosmic galaxies composed of cosmic matter or, as it is now rather inaccurately termed, anti-matter. These cosmic galaxies are exact counterparts of the material galaxies but they are not localized in space and we cannot see them. Cosmic gravitation operates to move units of cosmic matter toward each other in coordinate time, rather than in space, and the various cosmic masses therefore assume fixed relative positions in time, or move toward such fixed positions, but move away from each other in space, and the atoms of a cosmic galaxy are widely dispersed spatially.

It is probable that when the proper identifications of the particles already detected are made, the cosmic sub-atomic particles will all be accounted for experimentally, but little is yet known about any of the cosmic elements aside from those in the direct cosmic ray decay path, and beyond the normal c-elements there are a host of c-isotopes, c-ions, and other structures yet to be discovered. Furthermore, the cosmic elements are subject to combining forces of the same nature as those which are responsible for the great variety of chemical compounds in the material system, and in addition to individual units of the types shown in the compound motion diagram, cosmic chemical compounds exist in the same tremendous number and variety as the compounds of the material elements.

Whether or not the incoming stream of primary cosmic rays contains any appreciable number of such cosmic compounds is still uncertain, but there is an increasing amount of evidence indicating that compounds of cosmic and material elements are formed in the local environment. For example, the lambda meson (c-neon) is reported to participate in a number of combinations with various isotopes of hydrogen, which disintegrate after a brief existence. On the basis of current atomic theory these "hyper-fragments" are the result of replacement of an electron in the atomic structure by the lambda meson. According to the Reciprocal System, on the other hand, there are no individual "parts", in an atom, and both the electron and the meson are independent units of the same general nature as the atom. In this system the hyperfragment is a combination of the material atom and the meson: a cosmic-material chemical compound.

This suggests the interesting possibility of a direct test of the two conflicting theories, as current theory would indicate that it should be possible to produce an H^1 hyperfragment by substituting a meson for the lone electron which is supposed to exist in the H^1 isotope, whereas the Reciprocal System says that the simplest combination of this kind is one between the meson and the H1 isotope, which would be called an H^2 hyperfragment. On this basis an H^1 hyperfragment would be nothing but a lambda meson. Actually no H^1 hyperfragment has been detected, and the test therefore favors the Reciprocal System, as far as it goes. Unfortunately it is not conclusive, as it is always possible that the existence of the H^1 hyperfragment is barred for some other reason. However, proof of the existence of an H^1 hyperfragment would have been conclusive in the other direction, and it is highly significant that here again, as in so many other places throughout the numerous fields of physical science, whenever the new theory exposes itself to a fatal blow, that blow is never delivered; the opposition may be able to show the existence of a doubt because existing knowledge is incomplete, but it cannot demonstrate any direct conflict with known facts.

Addition of the structures discussed in this chapter to those shown on Chart D now completes the diagram of the compound motion system. All of the known primary units of the physical universe—particles, atoms, and modified forms of each—have now been placed in their proper positions in relation to the system as a whole. In view of the awkward position in which previous theories are now being placed by the many new particles that are currently being discovered by the experimenters, it is also interesting to note that the final diagram, Chart E, includes an immense number of different kinds of units that still remain undiscovered. This alters the balance between the theorist and the experimenter very decidedly. Instead of lagging far behind the experimental branch of science, as it has done for the past several decades, the theoretical branch, by virtue of the new developments reported herein, is now far ahead of the experimenters. It is clearly in order to designate this major improvement of the theoretical position as Outstanding Achievement Number Fourteen.

The completion of the compound motion chart also brings us to the end of our brief survey of the application of the Reciprocal System and its new concepts of space and time to the basic phenomena of the physical universe. Two additional chapters will follow, but they will be concerned with collateral aspects of the subject rather than

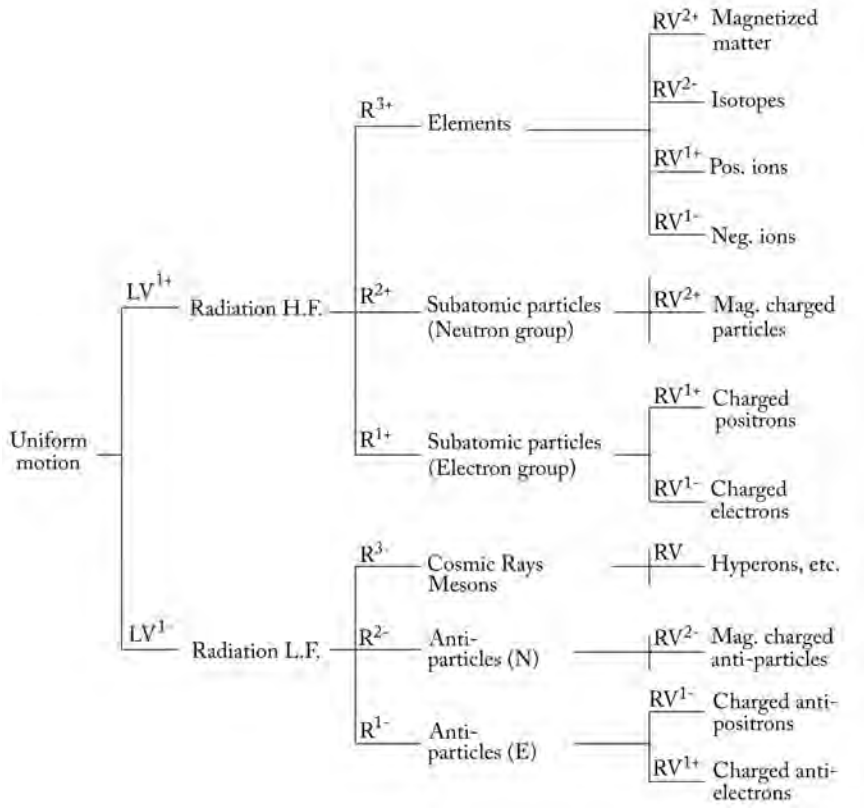


Chart E

continuing the descriptive process begun in Chapter VI. At this time, therefore, some general comments regarding the results, which have been attained by the new theoretical system, are appropriate.

In the concluding words of his physics textbook, John C. Slater expresses the ultimate goal of physical science as follows:

> And finally, we hope, some general theory will appear, so broad that all our present branches of physics appear as special cases of it.... We may hope that the progress toward this greater generalization will not be too discouragingly slow.[127]

Up to now, the construction of such a theory has never even been *attempted.* The most far-reaching aim ever seriously pursued by science has been that of constructing a "unified field theory" and even if that goal had been reached, the product would still fall far short of being the kind of a comprehensive theory that Slater calls for. There

would still have to be innumerable separate theories in individual physical fields, perhaps *related to* the unified field theory in the rather vague manner in which many of the individual theories now extant are related to Relativity or to some version of the quantum doctrines, but containing their own individual assumptions and "constants" just as existing theories now do.

The theoretical system described in this work is the first that has ever been presented as a complete general theory in the sense in which Slater is using the term: a general system of postulates which defines the basic properties of the universe and from which all subsidiary theories that are required in the individual fields of physical science are derived directly and in full form without the necessity of any supplementary or auxiliary assumptions within the separate fields. Here, for the first time, the structure of the atom is deduced from the same set of postulates as the structure of the galaxy, the expansion of the universe is explained by the same forces that account for the cohesion of solid matter, and the theories applying to the most distant regions of the universe are derived from the same general principles as the theories applicable to the most common everyday phenomena. Here, also for the first time, the nature of the basic entities of the universe—radiation, matter, electricity, magnetism, etc.—is *explained*, and the relation of these previously "unanalyzable" phenomena to the space and time of which the universe is constructed is specified in detail.

A question may be raised as to why the *first* general physical theory should claim to be the *correct* theory, in view of past experience which indicates that the first product in any field usually has a great many imperfections, which are eliminated only through a long process of improvement and modification. The answer is that the minimum requirements that a theoretical system must meet in order to justify presentation as a possible explanation *of the universe as a whole* are so stringent that it is out of the question for any such system to meet these minimum requirements unless it is correct in all essential respects. It is difficult enough for a theory to achieve full success in *one* field; few previous theories have ever successfully applied the same theoretical premises to *two* major physical fields; the requirement that a system must be applicable to *all* major fields, a requirement that must be met at least reasonably well before any system can even be advanced for consideration as a general theory of the universe, is simply prohibitive for anything other than the correct theory. It has therefore been necessary

for science to get along with separate and often conflicting theories in the various areas until the general state of knowledge advanced far enough to enable the correct basic theory to be formulated.

In order to accomplish the objective which Slater had in mind when he expressed the hope that a comprehensive general physical theory would shortly be forthcoming, it is not sufficient merely that such a theory be devised; it is also necessary that this theory should be *understood* and that it should be *recognized* for what it actually is. This is not as simple a matter as it might appear on first consideration, primarily because the general tendency, as Dyson pointed out in the observation previously quoted, is "to picture the new concept in terms of ideas which existed before," and on this basis *any* genuinely new idea in an existing field of knowledge seems absurd. A new theoretical system can be understood and appreciated only if it is examined *in its own context.* For instance, the contents of this present chapter make no sense at all if they are viewed in terms of atoms composed of "elementary particles," of motion taking place in space only, of space and time as components of a "four dimensional continuum," and so on. But if this chapter is examined in the context of the fourteen others that have preceded it, every item in the development fits in logically and harmoniously as a part of a complete and consistent theoretical system.

The new theoretical system presented in this work, the Reciprocal System, is precisely the kind of a product that the scientific profession has been asking for. All that is needed now is an understanding of the theoretical structure and recognition of the fact that it meets all of the specifications. Amending Slater's comments to bring them up to date, "We may hope that progress toward this understanding and recognition will not be too discouragingly slow."

CHAPTER XVI

Quantitative Relations

It is quite apparent that the quantitative aspects of the physical universe are determined by specific laws and principles in just as definite a manner as the qualitative aspects that have been our principal concern in the preceding pages. No school of scientific thought contends that the magnitudes of the many physical "constants" of one kind or another are the result of pure chance, nor that the numerical values determined for such properties of matter as specific heat, viscosity, or refractive index are accidental. But, with few exceptions, these values cannot be derived from purely theoretical sources in present-day practice; they depend in one way or another on some measured quantity.

Much progress has been made in the development of mathematical expressions to represent the variability of physical properties under different conditions. For example, Van der Waals' equation of state for gases, and the more complicated recent developments of the same kind, enable us to calculate the volume of a gas — methane, for example — under any specified conditions within a very wide range of temperatures and pressures. But in order to perform this calculation, using Van der Waals' equation, we must start with two purely empirical constants, which for methane are $a = 2.253$ and $b = .04278$. Just why these particular values apply to this particular compound is completely unknown. In fact, it is quite likely that they are merely determinants of an approximate mathematical relation and have no real physical significance.

This is typical of the general situation as it now exists. Present-day physical science can give us mathematical expressions of an empirical or semi-theoretical nature which represent the behavior of the properties of matter under various conditions, but only rarely can it give us a numerical value on which to base our calculations. Almost always we have to start with measured values of the properties in question or with empirical constants of one kind or another. Returning to the example previously cited, Van der Waals' equation is $(P + a/V^2)(V - b) = RT$. This is

mathematical, but as it stands it is not quantitative, and until it is made quantitative its value is quite limited. The major purpose of such an expression is to enable us to calculate one of the three quantities P, V and T if we know the other two, but this cannot be done until we establish values for the constants a and b, something that the theory underlying the equation is unable to do. In order to make this mathematical expression quantitative we have to call upon empirical sources for help. It is correct to say, therefore, that present-day theory, of which this is a fair sample, is mathematical, but it is not truly *quantitative*.

One of the important features of the Reciprocal System is that it is actually quantitative in the sense in which this term is used in the foregoing paragraph. The theoretical development deals with numerical values from the very beginning, and a quantitative treatment goes hand in hand with the qualitative treatment as the system expands into more and more detail. At the present stage of the development the quantitative results are not always as specific as those of a qualitative nature are. In many cases the theoretical calculations lead to a set of possible values rather than to one unique result, and the choice from among these several possibilities is determined by probability considerations which have not yet been given adequate study. This situation is further complicated by the fact that the numerical values of physical quantities are not always determined by present conditions; past history may also enter into the picture. For example, where two or more crystal forms of a substance may coexist through a range of temperatures and pressures, it is not possible, as matters now stand, to determine the crystal form of a particular specimen from theory alone, and many of the properties of the substance are affected by this crystal form. Presumably future studies will bring the probability factors and the problems connected with past history within the scope of the theory, but in the meantime the Reciprocal System carries us a long way into the quantitative field, even though it is not yet fully developed from this standpoint.

This present chapter is not intended as an actual quantitative development, which would take us far beyond the limits of the current volume, but as a brief description of how the quantitative phase of the theoretical development is carried out. One of the first things that is required for this purpose is to break down the various physical quantities into space-time terms so that their relations to the general

physical picture are clarified. We begin with one-dimensional space s and one-dimensional time t. Extension into additional dimensions then produces area s^2 and volume s^3, together with the corresponding time quantities t^2 and t^3, which have not been named. Dividing space by time, we obtain velocity s/t, and an additional division of the same kind results in acceleration s/t^2. Velocity in two dimensions s^2/t^2 and in three dimensions s^3/t^3 are not identified by special names.

Next we will want to look at the inverse quantities. The inverse of motion in our material universe is resistance to motion. Resistance effective in three dimensions is inertia or mass t^3/s^3, the inverse of three-dimensional velocity. Multiplying mass by velocity (mv) we obtain momentum t^2/s^2, and another similar multiplication (mv^2) gives us energy t/s. Energy is thus the reciprocal of velocity. Inasmuch as energy (or the equivalent quantity, work) is the product of force and distance, we have the relation $F = E/s$, hence force is t/s^2. Force is thus the analog of acceleration, with the space and time terms interchanged.

In the electrical field, we have found that the unit quantity of electricity, the electron, is simply a rotating unit of space. Electrical quantity is therefore s. Current, as already explained, is quantity per unit of time, and is therefore s/t, equivalent to a velocity. Electrical energy is equivalent to and interchangeable with energy in other forms t/s. Electromotive force, or electric potential, is likewise merely one form of force in general t/s^2. Energy per unit time is power $1/s$. The product of current and potential (IR) is resistance t^2/s^3. This quantity may also be defined in another way as mass per unit time.

Electric charge is not differentiated from electrical quantity in current practice because of the lack of recognition of the uncharged electron as the unit of current electricity, but these two quantities are quite distinct physically. The charge, being a unit of one-dimensional rotation, is the one-dimensional analog of mass and is therefore a quantity of energy t/s. Magnetic charge is similarly the two-dimensional analog of mass t^2/s^2. Magnetic potential, like electric potential, is charge divided by distance t^2/s^3. Does the distance divide the potential the potential gradient, or field intensity, for both electric and magnetic phenomena. The electric field intensity is

$$\frac{t}{s^2} \times \frac{1}{s} = \frac{t}{s^3}$$

Magnetic field intensity is

$$\frac{t^2}{s^3} \times \frac{1}{s} = \frac{t^2}{s^4}$$

Flux is defined in terms, which make it equal to charge, usually the product of the area and the field intensity:

$$\frac{t^2}{s^4} \times s^2 = \frac{t^2}{s^2}$$

Another basic magnetic quantity is inductance (L), which is defined by the equation

$$F = -L \frac{dI}{dt}$$

In terms of space and time, the inductance is then

$$L = \frac{t}{s^2} \times t \times \frac{t}{s} = \frac{t^3}{s^3}$$

Inductance is thus equivalent to mass. It is simply magnetic inertia. Because of the dimensional confusion now existing in magnetic relations it is usually regarded as equivalent to length, and is frequently expressed in centimeters. The true nature of this quantity can be seen if we compare the inductive force equation with the general force equation:

$$F = ma = m \frac{dv}{dt} = m \frac{d^2s}{dt^2}$$

$$F = L \frac{dI}{dt} = L \frac{d^2Q}{dt^2}$$

The equations are identical. As we have previously found, I is a velocity and Q is space. It follows that m and L are equivalent. We may now express the inductive force equation in space-time terms as

$$F = L \frac{dI}{dt} = \frac{t^3}{s^3} \times \frac{s}{t} \times \frac{1}{t} = \frac{t}{s^2}$$

The consistency of the relationships defined in the foregoing paragraphs can be demonstrated by similarly breaking down other force equations into their space-time equivalents:

EMF of current (Rate of change of flux)

$$F = \frac{d\phi}{dt} = \frac{t^2}{s^2} \times \frac{1}{t} = \frac{t}{s^2}$$

Magnetic force of current (Ampere's Law)

$$F = I\, dl \frac{M}{r^2} = \frac{s}{t} \times s \; \frac{t^2}{s^2} \times \frac{1}{s^2} = \frac{t}{s^2}$$

Force on moving charge

$$F = HQv = \frac{t^2}{s^4} \times s \times \frac{s}{t} = \frac{t}{s^2}$$

Magnetic force on conductor

$$F = HIl = \frac{t^2}{s^4} \times \frac{s}{t} \times s = \frac{t}{s^2}$$

The question naturally arises as to how it has been possible to express inductance in centimeters, or quantity of current in units of charge, or to utilize other such erroneous units, without getting into mathematical difficulties. An explanation that was used in a previous publication compares this with a situation in which we are undertaking to set up a system of units in which to express the properties of water. If it so happens that we fail to recognize that there is a difference between the properties of weight and volume, we will use the same unit—a cubic centimeter, let us say—for both. Since the specific gravity of water is fixed, this is equivalent to using a weight unit of one gram, and as long as we deal separately with weight and volume, each in its own context, the fact that the expression "cubic centimeter" has two entirely different meanings in our system will not cause any difficulty. But sooner or later we will want to use weight and volume at the same time, perhaps in order to utilize the concept of density, and then we will have trouble. Similarly, the conceptual errors in the electric and magnetic systems are of no consequence in ordinary practice, but they interpose some serious obstacles to a correct theoretical understanding of the phenomena that are involved.

An analogous situation exists with respect to Planck's constant h. This constant is expressed in erg-seconds, the product of energy and time, or *action*, as it is called. In space-time terms action is t^2/s. This is, in itself, an oddity, as none of the other basic quantities that have been discussed in the previous pages has a higher power in the numerator of the space-time relation than in the denominator, and it strongly suggests that action does not have the same kind of physical significance as these more familiar quantities. Furthermore, the concept of action does not help us to *understand* the relation between energy and frequency; all that we have here is *mathematical* knowledge, the knowledge that there is a definite proportionality between the two quantities. Giving the constant of proportionality the name "action" and the dimensions energy × time does not contribute any *conceptual* information about the relationship.

In order to gain a genuine understanding of the situation it is necessary to recognize the true physical nature of the so-called "frequency." From the facts previously developed it is apparent that this is actually a *velocity,* a relation of space to time, not a function of time alone. The true statement of Planck's radiation energy equation is therefore E = hv. The constant h is then equal to E/v, or in space-time terms

$$h = \frac{t}{s} \times \frac{t}{s} = \frac{t^2}{s^2}$$

These are simply the reversing dimensions required to convert velocity s/t into its reciprocal, energy t/s. The constant h in the radiant energy equation has the same dimensions and serves the same purpose as the momentum mv in the kinetic energy equation:

$$E = \frac{1}{2}mv^2 = \left(\frac{t^3}{s^3} \times \frac{s}{t}\right) \times \frac{s}{t} = \frac{t}{s}$$

$$E = hv \quad = \quad \frac{t^2}{s^2} \quad \times \frac{s}{t} = \frac{t}{s}$$

Another source of dimensional confusion is the lack of recognition of the dimensionless character of some of the terms in the equations for electric, magnetic, and gravitational forces. The dimensions of electric potential, for example, are given in the handbooks as $\varepsilon^{-1/2} m^{1/2} l^{1/2} t^{-1}$ on the assumption that the mass and charge terms in Coulomb's Law and its multi-dimensional counterparts all have mass and charge dimensions. This is not correct, as a close examination of the gravitational equation clearly shows. If such an assumption is applied to this equation, the gravitational force is proportional to the square of the mass, whereas the general force equation F = ma says that *any* force is directly proportional to the mass involved. Obviously there is something wrong.

An analysis shows that the dimensional situation has not been properly assessed in arriving at the currently accepted conclusions. A mass m exerts m units of force on unit mass at unit distance, and it exerts m' times as many units of force on m' units of mass at the same distance, not m' grams times as many units of force but merely m' times as many. In other words, one of the mass terms in the equation, m' in this case, is simply a dimensionless ratio, the ratio of m' units of mass to one unit of mass. The distance term in the equation is likewise a ratio, the ratio of d^2 units of distance to 1^2 units of distance, as can easily be seen on consideration of the derivation of the inverse square relation.

If we eliminate the dimensionless terms from the gravitational equation; that is, set up an equation for the force exerted by a mass m

on unit mass at unit distance, we have F = km. A previously published study of this relation indicates that acceleration also enters into this situation, but that it is the acceleration due to the force of the space-time progression, and it always has unit value, hence has no numerical effect, and for this reason has not hitherto been recognized. The acceleration term should be inserted to complete the gravitational equation from a dimensional standpoint, and we then have F = kma, which is identical with the general force equation as, of course, it should be.

The key to the quantitative aspect of the new theoretical system is the postulate that space and time exist only in discrete units. From this basic principle it follows that the displacements of space and time which are responsible for the existence of all physical phenomena consist of a specific number of units of space (or time) associated with a specific number of units of time (or space), and the successive additions of different kinds of motion which build up the compound unit as shown on Chart E are actually additions of units of motion (displacement). Matter, for instance, does not exist in an infinite gradation of quantities; it exists only in a series in which the first member has one net unit of positive three-dimensional rotation and each succeeding member adds one more unit of the same kind. The properties of the individual members of this series, the series of chemical elements, are determined by the way in which the rotation around each of the three axes of the atom is built up by successive addition of separate units of motion, with the sequence of assignment of units to the different axes following a specific pre-determined pattern.

The same kind of an orderly addition of units exists all through the theoretical development, and the specific number of units of each kind of motion present in an atom or other physical entity is the factor that determines the quantitative properties of that entity. All subsequent numerical values result from mathematical relations between the basic entities and are derived entirely from combinations and other systematic modifications of the original displacement values. Because of this manner in which the quantitative relations are developed, no arbitrary or measured numerical values are introduced at any point. Aside from the conversion constants which are required if the results are to be expressed in some conventional system of units rather than in the natural units in which they originally appear, all numerical constants which enter into the theoretical relations are

structural constants: integral or half-integral values which represent the actual numbers of the various types of physical units entering into the particular phenomenon under consideration.

To illustrate how the quantitative aspects of the various physical phenomena originate, the development of the series of chemical elements will serve as a good example. As brought out in Chapter VI, the atom of matter is a linear oscillation (LV^{1+}) rotating in three dimensions (R^{3+}). When we examine the details of this rotation, however, we find that, although it is rotation in three dimensions, it is not, strictly speaking, a three-dimensional rotation. A line cannot rotate around itself as an axis, as such a rotation would be indistinguishable from no rotation at all. The linear oscillation therefore rotates around its midpoint. One such rotation generates a two-dimensional figure, a disk. Rotation in another dimension generates a three-dimensional figure, and in order to make three-dimensional rotation possible it would be necessary to have a fourth dimension available. Since there is no fourth dimension in the physical universe, the basic rotation of the atom is two-dimensional.

Once a two-dimensional rotating unit is in existence, however, it is possible to add oppositely directed motions of various kinds in the same way that the compound motions of Chart E are built up. One of the possibilities that is open is the rotation of the two-dimensional unit around the third of the three perpendicular axes. This oppositely directed one-dimensional rotation is not necessary; that is, the two-dimensional unit may exist without any effective rotational displacement in this third dimension. (A rotation at unit velocity is the rotational zero, just as unit linear velocity is the physical zero for translational motion.) The possible rotational combinations therefore include both purely two-dimensional units and units with both one-dimensional and two-dimensional rotation.

Another important point is that two separate two-dimensional rotations may be combined in one physical unit. The nature of this combination can be clearly illustrated by two cardboard disks interpenetrated along a common diameter C. The diameter A perpendicular to C in disk A represents one linear oscillation, and the disk A is the figure generated by a one-dimensional rotation of this oscillation around an axis B perpendicular to both A and C. Rotation of a second linear oscillation, represented by the diameter B. around axis A generates the disk B. It is then obvious that the primary rotation

represented by disk A may be given a secondary rotation around axis A and the primary rotation represented by disk B may be similarly rotated around axis B without interference at any point, as long as the rotational velocities are equal.

Here, again, the second rotation is not necessary for stability. Units in which there is only one two-dimensional rotation can and do exist. But, as a general principle, symmetrical combinations are more probable than asymmetrical combinations. A 1-1 combination, for example, is inherently more probable than a 2-0 combination, and if a second two-dimensional displacement unit is added to a 1-0 combination—a unit with a single two-dimensional rotation—it is highly probable that the new unit will generate a rotation around the second axis, bringing the combination to the 1-1 status, rather than raising it to 2-0 by adding to the existing rotation. This probability is further heightened by the fact that the rotation that is to be absorbed will itself be a combination of a linear oscillation and an added rotation so that the increase from 1-0 to 1-1 is a simple absorption of the entire rotating unit, whereas a change from 1-0 to 2-0 involves some kind of a readjustment. The addition of these two factors creates such a strong bias in favor of the symmetrical distribution that the alternative distribution is, in effect, barred. The combinations with only one two-dimensional rotation are therefore confined to those, which do not possess more than one unit of rotational displacement.

With the benefit of the foregoing information, we are now ready to start identifying the possible rotational combinations; that is, the possible material atoms and sub-atomic particles. As a preliminary step, however, it will be desirable to define some convenient terms and symbols which will facilitate the discussion. For reasons, which should be apparent from the points brought out in the preceding chapters, the one-dimensional rotation will be designated as electric and the two-dimensional rotation as *magnetic*. In order to avoid interference it is necessary that the two rotating systems of the atom have the same velocities. Each added unit of magnetic displacement therefore increases the rotation of both systems in one magnetic dimension rather than one system in both dimensions. In those cases where the displacements in the two dimensions are unequal the rotation is distributed in the form of a spheroid, and where this is true the rotation which is effective in two dimensions of the spheroid will be called the *principal* magnetic rotation and the other the *subordinate* magnetic rotation.

In referring to the various combinations of rotational displacement a notation in the form 2-2-3 will be utilized, the three figures representing the displacements in the principal magnetic, the subordinate magnetic, and the electric rotational dimensions respectively. Where the displacement is in space instead of in time, the appropriate figure will be enclosed in parentheses. It should be understood that the terms "electric" and "magnetic" refer only to rotation in one and two dimensions respectively, and neither term implies the existence of a charge. Where a charge is present, this will be so stated.

This may also be an appropriate place to insert another reminder of the nature of such presentations as the one that follows. This is not a *hypothesis* as to what exists in the actual world; it is a description of what *actually* exists in the *hypothetical* world. The general principles controlling the combinations of rotational motions, as set forth in the preceding paragraphs, are the principles, which must hold good in the theoretical RS universe. Of course, the general proof of the identity of the RS universe and the observed physical universe means that all of the conclusions also apply to the latter but it should be remembered that the description which follows is entirely theoretical; no part of it is derived from observation or from inferences based on observation. The exact agreement with the observed facts is therefore a reflection of the accuracy of the theory, not a testimony to the ingenuity of the originator.

If a linear oscillation is given a rotational motion with a single unit of magnetic displacement, the resulting combination 1-0-0 is the rotational base. In this combination the single rotational displacement merely neutralizes the vibrational displacement in space, and the net displacement is zero; that is, this unit is the rotational equivalent of nothing at all. In accordance with the general principles previously stated, the addition of another magnetic displacement unit produces 1-1-0, which we identify as the neutron, the neutral magnetic sub-atomic particle.

Still another magnetic displacement unit results in 2-1-0. Here, for the first time, we have an *effective* displacement in both magnetic dimensions, and this combination therefore has some properties, which are quite different from those of the neutron. These properties we identify as the characteristics of *matter* and we identify the combination 2-1-0 as the element helium. Further additions of magnetic displacement, going alternately to the two magnetic dimensions, produce a series of elements, which we identify as the inert gases. The complete series is as follows:

Displacement	*Designation*
1-0-0	Rotational base
1-1-0	Neutron
2-1-0	Helium
2-2-0	Neon
3-2-0	Argon
3-3-0	Krypton
4-3-0	Xenon
4-4-0	Radon
5-4-0	Unstable

The electric equivalent of a magnetic displacement n is n^2 in each dimension. The symmetry principle therefore tells us that the magnetic rotation is more probable than electric rotation where the option exists. As a consequence, the role of electric rotation is confined to filling in the intervals between the members of the foregoing series.

Here there is a mathematical point that must be taken into consideration. In the undisplaced condition, all progression is by units. We have first one unit, then another similar unit, yet another, and so on, the total up to any specific point being n units. There is no individual term with the value n; this value appears only as the total. The progression of displacements follows a different mathematical pattern because in this case only one of the space-time come portents progresses, the other remaining fixed at the unit value. The progression of $\frac{1}{n}$, for instance, is $\frac{1}{1}$, $\frac{1}{2}$, $\frac{1}{3}$, and so on. The progression of the reciprocals of $\frac{1}{2}$ is 1, 2, 3... n. Here the quantity n is the final term, not the total. For the total we must sum up all of the individual terms. Similarly, when we find that the electric equivalent of a magnetic displacement n is $2n^2$, this does not refer to the total from zero to n; it is the equivalent of the nth term alone. From the foregoing it is evident that if all rotational displacement were in time, the complete series of elements would start with the lowest possible magnetic combination, helium, and the electric displacement would increase step by step until it reached a total of $2n^2$ units, whereupon the relative probabilities would result in the conversion of these $2n^2$ units of electric displacement into one additional unit of magnetic displacement, and the building up of the electric displacement would then be resumed. This behavior is modified, however, by the fact that electric displacement in matter, unlike magnetic displacement, may be in space rather than in time.

The net rotational displacement of any material atom must be in time in order to give rise to those properties which are characteristic

of matter. It necessarily follows that the magnetic displacement, which is the larger component of the total, must also be in time. But the smaller component, the electric displacement, *may* be in space without affecting the direction of the net total displacement. Which direction the electric displacement will actually take in any particular situation then becomes a matter of probability. Since the probability factors favor the lower number of units, we can deduce that successive additions to the net total time displacement from any inert gas base will take the form of electric displacement in time until n^2 units have been added. At this point the probabilities are nearly equal and the alternate situation may exist. As the net displacement rises still farther, the alternate arrangement becomes more probable, and in the second half of each group the magnetic displacement is increased by one unit and an appropriate number of units of the oppositely directed displacement in space brings the net total down to the required figure. Successive units of this space displacement are then eliminated to move up the atomic series.

By reason of this availability of electric space displacement as a component of the atomic structure, an element with a net displacement less than that of helium becomes possible. This element 2-1-(1), which we identify as hydrogen, is the first member of the series of chemical elements. Each succeeding member of the series adds one unit of electric time displacement or the equivalent thereof. Helium is element number two. At this point the displacement is one unit above the initial level of 1-0-0 in each magnetic dimension and any further increase in the magnetic displacement requires the addition of a second unit in one of the dimensions. Where n = 2, the electric equivalent of the added magnetic unit is 8, and hence there are eight elements in the next group, as follows:

Displacement	*Element*	*Atomic Number*
2-1-1	Lithium	3
2-1-2	Beryllium	4
2-1-3	Boron	5
2-1-4 2-2-(4)	Carbon	6
2-2-(3)	Nitrogen	7
2-2-(2)	Oxygen	8
2-2-(1)	Fluorine	9

Another similar group with one additional unit of magnetic displacement follows, then two groups of 18 units each (n = 3) and two groups of 32 elements each (n = 4). As indicated in Chapter XIII, the atoms of the last of these groups are radioactive, and the instability increases rapidly as the atomic number approaches 100. The relatively few elements near and above 100 that have been identified are therefore known mainly through artificial production of extremely short-lived isotopes. A full listing of the elements of these upper groups does not appear necessary for present purposes, but the following tabulation shows the first and last members of each group and the element at the midpoint:

Displacement	*Element*	*Atomic Number*
2-2-1	Sodium	11
2-2-4	Silicon	14
3-2-(1)	Chlorine	17
3-2-1	Potassium	19
3-2-9	Cobalt	27
3-3-(1)	Bromine	35
3-3-1	Rubidium	37
3-3-9	Rhodium	45
4-3-(1)	Iodine	53
4-3-1	Cesium	55
4-3-16	Ytterbium	70
4-4-(1)	Astatine	85
4-4-1	Francium	87
4-4-16	Nobelium	102
5-4-(1)	Unknown	117

By a similar process of addition of electric displacement in time and space to the rotational base and the neutron we may complete the list of sub-atomic particles in the material system as follows:

Displacement	*Designation*
1-0-(1)	Electron
1-0-0	Rotational base
1-0-1	Positron
1-1-(1)	Neutrino
1-1-0	Neutron
1-1-1	Unnamed particle

The development of this systematic quantitative explanation of the series of chemical elements is clearly entitled to be designated

as Outstanding Achievement Number Fifteen, not only because it is important in itself, inasmuch as it provides definite answers to longstanding questions as to why such a series exists, why it includes these specific elements and not others, why some, but not all, of the properties of these elements are periodic, and what factors determine the magnitudes of those properties, but also because it provides a point of departure for a host of other quantitative developments.

Through the addition of successive units of rotational displacement in accordance with the sequence that has been described, the only way in which these units can be added in conformity with the principles of the Reciprocal System, each of the chemical elements acquires its own individual pattern of displacements in the different dimensions. The numerical values of these displacements are then the figures that enter into the quantitative expressions of the various physical properties, and since each element has its own set of figures each has a unique quantitative pattern.

The series of elements is first established by successive additions of units of displacement, beginning with one effective unit and ending with 117. This gives each element one unique numerical value which enters into a great variety of mathematical expressions of physical properties and makes the quantitative result for that element different from that of any other. But for other purposes the significant value is not the net total displacement but the displacement in some one or more of the rotational dimensions, and because of the definite and specific factors which determine the particular rotation to which each successive displacement addition goes, each element also has its own individual pattern of rotation values. The quantitative aspects of the elementary physical properties such as mass, volume, etc., are determined directly by one or more of these four numerical values that characterize the individual elements. More complex quantitative relations are then established by interaction between the elementary values in much the same manner as the proliferation of qualitative relations previously discussed.

The mass of the normal atom, for example, is a function of the net total time displacement, and it increases continuously with the atomic number. The index of refraction and the diamagnetic susceptibility are functions of the magnetic displacement alone, and they also increase as the atomic number rises, but discontinuously and much more slowly. The

inter-atomic distance in the solid state is likewise a direct function of the magnetic displacement, but it is also an inverse function of the electric displacement and this makes it a periodic property. The atoms are widely separated in the first element of each rotational group (sodium, etc.) and the inter-atomic distance decreases to a minimum at the midpoint of the group, increasing again thereafter, so that the separation in the last element (chlorine, etc.) approximates that in the first.

In the past the biggest obstacle to the development of a quantitative system which could reproduce the magnitudes of physical properties by means of relations based entirely on theoretical foundations has been the lack of any known numerical characteristics of the elements other than the atomic number. Many *ad hoc* constructions, such as "electron shells," for example, have been devised in an attempt to provide these additional numerical values but, from a practical standpoint, it is virtually impossible to solve a complicated problem by ad hoc methods. The typical results of this method of approach are graphically, if somewhat unintentionally, portrayed by an author who summarizes the application of quantum mechanics to the "electron shell" and related atomic and molecular concepts with the enthusiastic statement that "Quantum mechanics … gives the solution, in principle, to almost every chemical problem," and then almost in the same breath, admits that "Very unfortunately, however, there is an enormous gap between this solution in principle and the practical calculation of the properties of any specific molecule."[128]

Such solutions "in principle" are fraudulent. If a "solution" does not produce the right answers, then it is not a solution in fact, and calling it a solution *in principle* is a gross misuse of the word "solution." The purpose of a physical theory is to produce the right answers; if it produces the wrong answers then the theory itself is wrong, both in principle and in fact. The only feasible route to success in solving a very complex problem such as that of the properties of matter is by way of a theory which is correct in all respects from the very beginning. This is what the Reciprocal System now provides. In this system the basic combinations of values applicable to each element are not derived from an ad hoc manipulation of empirical results, but are derived theoretically from the properties of space and time. Thus they have the firm theoretical basis that is essential in order to produce the correct results in such a vast and complex field.

Furthermore, the scope of the practical applicability of the new system is broadened to a very considerable degree by the extraordinary simplicity of the basic relations that have been established. This was a rather unexpected aspect of the theoretical development, since the phenomena under consideration are, as a rule, very complicated, and it is only natural to assume that this is the result of a complex underlying relationship. One of the reasons why we hear so much about solutions "in principle" is that the mathematical expressions which have been developed in an attempt to express these complex relations become so unwieldy in practical application that they cannot be handled by available mathematical techniques, and it is normally impossible to carry the calculations to completion so that it can be determined specifically whether the theories are correct or not. But the new development now shows that in most cases where properties of a basic nature are involved, the complex relation that we observe is actually a combination of two or more relatively simple relations.

For example, the volumetric pattern of water is so complicated that P. W. Bridgman, the foremost investigator in this field, expressed serious doubt that it would *ever* be possible to reproduce this pattern mathematically.[129] A study based on the principles of the Reciprocal System reveals, however, that this is not *one complex pattern* as Bridgman assumed; it is a composite of *four simple patterns:* the characteristic linear relation of the liquid state, a probability distribution representing the proportion of solid molecules in the lower liquid range, another probability distribution representing the proportion of critical molecules in the upper liquid range, and a third probability distribution originating from the fact that there are two forms of the water molecule—a high temperature form and a low temperature form—within the liquid range. When the four factors are separated and each is treated according to its own simple rules of behavior, Bridgman's "impossible" task can be, and has been, accomplished.

Unraveling such a tangle of relations is, of course, a major undertaking, but it is a relatively straightforward task that can hardly fail to reach its objectives if sufficient effort is applied. Since the new theoretical system accomplishes a similar simplification in a great many physical fields, it opens the door to almost unlimited progress along quantitative lines.

CHAPTER XVII

A Philosophical Postlude

It is both interesting and significant that the traditional home of college courses on "Space and Time" is the Philosophy Department, not the Scientific School. In order to appreciate to the full extent what a strange situation this actually is, we might compare the task of science in systematizing our knowledge of the universe to some physical construction project–the construction of a building, let us say. Before a building can be started, there are many things to be done; there has to be a decision to build, a site has to be selected, financing must be arranged, and so on, all of which are necessary, yet not, strictly speaking, part of the actual building construction. These items are analogous to the normal tasks of the philosophers in connection with science. It is their job to take care of the preliminaries, which precede the actual construction of the framework of physical theory by the scientists.

But space and time do not belong in this category at all. In terms of the building analogy, they correspond to the bricks of which the building is to be constructed. They are essential elements in the physical structure of the universe, the study of which constitutes the primary task of science, and they cannot legitimately be relegated to any other discipline, no matter how closely related. In leaving the foundations of their theoretical structure to the philosophers, scientists are putting themselves in the same position in which engineers would be placed if they left the construction of the foundations of their structures to the financiers.

The truth is, of course, that space and time have not been left to the philosophers because of any feeling on the part of scientists that they belong in the Philosophy Department. Science has simply been at a loss to know what to do with them, because the available knowledge as to their nature and properties has been too meager and too uncertain to permit treating them by normal scientific methods. The philosophers have therefore acquired these subjects by default,

not because they are non-scientific or meta-scientific, but because they are hard to pin down specifically. Space and time are scientific *de jure*, but in present-day practice they are philosophical *de facto*. One of the accomplishments of the Reciprocal System has been to bring space and time back into science where they belong. As pointed out in connection with the cosmic ray discussion, a very important advantage of a complete theoretical system of this kind is that it can be verified in its entirety by tests carried out in the areas accessible to accurate observation, and after this is done, its application can be extended to relatively unknown regions with the assurance that its conclusions are equally valid in these regions. Thus we can determine exactly what roles space and time play in the theoretical RS universe and since we have established the identity of this universe and the observed physical universe, we then know that these are also the roles of space and time in the physical universe. What are space and time' is an age-old question that has produced an amazing variety of answers, few of which are even vaguely scientific.

What are time and space? They are the names for ways of conducting certain measurements. (Whitehead)[130]

> Time has been interpreted in an almost infinite variety of ways and no one single statement can do more than picture it from one point of view. (Merriam)[131]
>
> The universe changes, and time is a process that brings new out of old. (Schlegel)[132]
>
> A physicist nowadays thinks of space as a collection of relations of a special kind between objects. (Thomson)[133]
>
> The idea of time in its most primitive form is probably the recognition of an order of sequence in our states of consciousness. (Maxwell)[134]
>
> In recent science time is treated as an additional dimension of space. (Hering)[135]
>
> Space-Time is the stuff of which matter and all things are specifications. (Alexander)[136]
>
> "Time is the independent variable in the laws of mechanics." This is the very best definition that can be given of time. (Margenau)[137]

The long-standing conflict between the supporters of the absolute and relational theories of space and time is an outgrowth of this uncertainty as to the true nature of these entities. Whether space and

time are logically prior to events or are determined by events has been a bone of contention for more than two thousand years, but now that the Reciprocal System gives us a definite and unequivocal answer to the basic question, neither of these theories can be accepted in its entirety. Space and time in the RS universe are the two reciprocal aspects of motion. But "events" as the term is customarily used in this context, are motions of one kind or another. Space and time, then, are *neither* relational, in the sense of being determined by events, nor absolute, as defined by Newton. There is a general framework of the universe, an extension space, generated by translational motion, which is essentially equivalent to Newton's absolute space, but other types of motion also have spatial aspects, and extension space is therefore only one phase of space in general. The absolute and relational concepts over which the long argument has raged are simply inadequate to comprehend the full range of time and space.

The question as to whether space and time are finite or infinite is another, which previously existing theories have been unable to answer conclusively. The existence of zero space and zero time is generally conceded and no controversy has ever developed over these concepts comparable to that which has raged over the question as to the existence of infinite space or time, but the development of the Reciprocal System now shows that the two are simply different aspects of the same thing. Infinite space is equivalent to zero time and vice versa. To most scientists, the ability of an object to remain stationary in space, relatively if not absolutely, seems altogether logical, yet the new theoretical system says that this involves infinite time; that is, no motion at all is equivalent to taking infinite time to move one unit in space. In the new system all other manifestations of infinite space and time have essentially this same character.

It should be noted, however, that whether the *universe* is finite or infinite in extent is an altogether different question. Undisplaced space-time is the physical equivalent of nothing at all, and when we speak of the universe we normally refer not to space-time as such, but to the aggregate of those space-time displacements which manifest themselves primarily as matter or c-matter. As we have seen, the existence of matter is limited in time; that is, the giant galaxies into which the oldest matter in the material sector collects ultimately explode and initiate a process, which converts the old matter into new

cosmic matter. The existence of cosmic matter is similarly limited in space. We must therefore conclude that the universe, as herein defined, is finite in extent, even though the space and time in which it exists and of which it is composed are, in a sense, infinite.

As brought out in Chapter XIV, the new findings also indicate that the universe is in a steady state rather than undergoing any one-way process of evolution. A special word of caution is appropriate at this point. Decision between the evolutionary and continuous cosmological theories does not have any implications at all with reference to the question as to whether or not an act of creation has taken place. There has been a tendency on the part of the theologians and scientists with strong religious beliefs to favor an evolutionary hypothesis on the ground that this implies a beginning of the universe, which can be correlated with creation, whereas a hypothesis that pictures the universe as without beginning and without end seems to conflict with the creation doctrine. The truth is, however, that neither hypothesis has any bearing on the creation issue one way or the other. If the present epoch of the universe originated with an explosion as postulated by Lemaitre, this is still not a beginning; the problem of the origin of the material, which exploded, still remains. The evolutionary hypothesis does not, in any way, resolve the creation problem.

Neither does the steady state hypothesis complicate it. There is no visible reason why the creation of a universe that remains in a steady state after it is created should be any less plausible than the creation of an evolutionary universe. In some respects the findings of this work actually simplify the creation issue. The hotly debated question as to what was happening *before* the creation, for instance, no longer has any significance, since it is evident that, if the creation occurred, it was space-time itself that was created, as St. Augustine contended centuries ago, and hence the concept of "before" did not acquire any meaning until the creation took place.

What the Reciprocal System has done with respect to the issues that have been discussed thus far in this chapter (excluding the question of creation, which is outside the realm of science) is to remove them from philosophy, put them back into science where they belong de jure, and fit them into their proper places in the definite and specific theoretical framework that has been constructed for the universe as a whole. But the clarification that has been accomplished in this area where

philosophy and science have to some degree overlapped is not all that the new development has accomplished of interest to philosophers. Another thing that it has done is to throw some additional light on the application of philosophy to science.

One of the noteworthy facts about modern science is that some of its most spectacular and widely hailed results have been achieved by the use of methods or concepts, which have been opposed, or at least disapproved, by the philosophers. (For present purposes we are excluding from this category those individuals whose aim is to derive a philosophy *from* science rather than to apply philosophical principles *to* science.) The following statements bring out the nature of some of these differences of opinion:

> The divergences between physicists and philosophers have become very clear recently. We have only to glance at the discussions about space, time and causality connected with relativity and the quantum theory to see this. (Frank)[138]
>
> When we start postulating strange things about the world, justifying our choice not by explaining the matter properly but resorting to a mystique, we should beware. We know that our knowledge and experience are limited, but that is not reason enough for our being imposed on to accept formulas for interpreting successful technical inventions when the interpretation strains language and seems not to make sense to us. (Watson)[139]
>
> I believe that the conceptual structure of quantum mechanics today is as unhealthy as the conceptual structure of the calculus was at the time Berkeley's famous criticism was issued. (Putnam)[140]
>
> There is no reason whatever why a future atomic theory should not return to a more classical outlook without contradicting actual experiment, or without leaving out facts already known and accounted for by wave mechanics. (Feyerabend)[141]
>
> The conceptions introduced by Einstein must accordingly be admired to the extent that they constitute a powerful physico-mathematical synthesis; but they must be rejected if given properly philosophical meaning. (Marilain)[142]
>
> The physicist has made his choice in rejecting as basically incorrect the classical description of motion. The philosopher has not always been willing to follow him. (Margenau)[143]
>
> Primitive notions such as those of time and space … always trouble the philosopher, who dislikes seeing elaborate structures reared on shaky foundations. (Lindsay)[144]

> Quantum physics, I submit, presents a strong case against traditional logic. (Waismann)[145] There is no convincing instance of the alleged need to change the laws of logic in order to achieve better conformity of theory and fact. (Feigl)[146]
>
> The old conflict between absolute and relational space, while still alive in philosophic discussions, is settled and dead in science. (Margenau)[147] What men of one generation are pleased to regard as satisfactorily settled may be questioned by a succeeding one so the philosopher is not disposed to accept the confidence of the scientist with his enthusiasm. (Watson)[148]

The astounding thing about these conflicts between the conclusions of the philosophers and those of the scientists is that in every one of the instances cited, the findings of this present investigation are that the philosophers are right, or partially so, and the scientists are wrong. This does not imply that the philosophers are *always* right when there is a conflict of this kind. The foregoing list is by no means a complete catalog of such conflicts, nor is it necessarily true that the opinions of the authors quoted are representative of the majority opinion in the particular field; this is merely a sample collected somewhat randomly from the literature of the two professions. But there is enough evidence here to indicate that the broad general principles of philosophy, in spite of their largely intuitive and unverifiable nature, provide more reliable guidelines than many of the conclusions of present-day science.

However distasteful this conclusion may be to the scientific profession, it is not entirely unprecedented. Heisenberg, who can hardly be described as prejudiced against the scientific viewpoint, has are rived at much the same conclusions with respect to the relative reliability of the language forms of scientific usage as compared to those in common use. In this connection he comments: "The concepts of natural language, vaguely defined as they are, seem to be more stable in the expansion of knowledge than the precise terms of scientific language, derived as an idealization from only limited groups of phenomena."[149] The underlying principle is the same in both cases: a vague, but essentially correct, formulation is more reliable than a precise, but erroneous, formulation.

It does not follow that philosophy is inherently more trustworthy than science. On the contrary, science has an important advantage in that a reasonable degree of certainty attaches to many of its findings, and the zone of certainty is continually growing—indeed, the primary

objective of the present work is to contribute toward this result. Where science can speak with certainty, it speaks authoritatively. The conflicts such as those cited do not arise in this zone; they occur in those areas where science is *positive without being certain,* areas, which are particularly extensive in so-called "modern" science.

As Heisenberg points out in the statement just quoted, scientific conclusions rest on a very narrow base; they are derived from "only limited groups of phenomena." It logically follows, therefore, that an extraordinary degree of care ought to be taken in the critical examination of these conclusions in order to make certain that they are at least consistent with the limited number of facts which are available for comparison before accepting them on anything more than a tentative basis. Even this special attention to the verification process would not entirely compensate for the inadequacy of the basic data, but it would at least make a contribution toward that result. However, the modern scientist rejects this view of the situation and takes the stand that his methods and procedures are so powerful that the conclusions, which he reaches, are incontestable and should be exempt from the necessity of confirmation. The following quotation from Margenau expresses this present-day viewpoint:

> Though it may seem strange to the logician, scientists are none too meticulous in their demands for sufficiency in the number of validating instances.... Reliance upon the logical coherence of his conceptions exempts the scientist from the need of exhaustive "verification. There is an important sense in which a theory is more than the class of sentences it can generate, and the awareness of this transcendency inclines scientists to unhesitating acceptance of a theory after it has been subjected to a number of tests which are wholly inadequate statistically.[150]

Just why the "conceptions" of the physical scientist should be inherently more "logically coherent" than those of anyone else is rather difficult to understand. The ancient jest about the individual who does not have to *prove* that he is right because he freely *admits* it seems to have here made its appearance in all seriousness. The point that Margenau and his colleagues are overlooking is that sound or "coherent" reasoning does not guarantee sound conclusions; on the contrary, the better the reasoning process the more certain it is to arrive at the wrong conclusions if, as in this instance, it starts from the wrong premises. The revolutionary" conclusions of modern physics are wholly dependent on

the premise that all possible alternatives to these conclusions have been located, examined, and rejected. As this present work demonstrates, this premise is altogether false. There *are* other alternatives in every case, and the completely unexpected nature of most of them is a graphic demonstration of the fact that the scope of the human mind is still severely limited. No system of human thought, scientific or otherwise, has yet reached the stage where it is completely self-sufficient. It is not yet possible to be sure that all aspects of any particular issue, or all alternative explanations of any particular situation, have been covered, or that the chain of reasoning that has been utilized is flawless.

The preceding pages are full of instances that confirm the foregoing statements and illustrate the fallibility of scientific conclusions. For hundreds of years scientists have been convinced that gravitation must either be due to action at a distance or else must be propagated through a medium, or the equivalent of a medium, at a finite velocity. The most careful study of the situation by the most capable men in the profession over a long period of time has failed to produce any other plausible alternative, and this has been accepted as a clear indication that no such alternative exists. But in all of this scientific consideration of the problem it has been taken for granted that gravitation is an action of one mass upon another, and the investigators have been unable to rise far enough out of the traditional channels of thought to realize that this is not necessarily true; that it is merely an assumption *suggested* by the observed phenomena. By widening the horizons of thought to take other possibilities into account this present development has been able to produce a logical, consistent, and workable alternative in this case where modern science has been positive that there was no alternative.

Essentially the same thing has happened with respect to the problem of explaining the constant velocity of light. Scientists have been completely convinced that they have made a "thorough-going analysis of all conceivable alternatives,"[56] and have therefore concluded that Relativity, which seems to be the most plausible of these '"conceivable alternatives" must be correct. Here again many of the things that are taken for granted in the consideration of the problem are merely assumptions, but the investigators have been unable to visualize the possibility that one or more of these assumptions might be in error. As in the case of gravitation, this work has taken a broader view of the situation and has found that by so doing it becomes possible here,

also, to discover a logical, consistent, and workable alternative where present-day science is positive that no alternative is "conceivable."

Since these and the many other similar instances that can be found in the preceding pages clearly demonstrate that the human mind, be it scientific or non-scientific, has not yet reached the point where it can safely assume that it has exhausted the possibilities in any such investigation, it follows that *the negative conclusions of science are inherently unreliable*. Statement of an established *positive* principle in negative *form* is entirely acceptable. The statement that a perpetual motion machine is impossible, for example, is actually an expression of a firmly established conservation law. But when science says that it is impossible in principle to assign both a definite position and a definite momentum to a particle, or that it is impossible to detect absolute velocity, or that it is impossible to find any causal relationship leading to the radioactive disintegration of a particular atom, or makes some other statement of this nature, it is making an assertion which rests entirely on the premise that what scientists have not been able to do cannot be done: an inferential claim to infallibility that is not only completely unwarranted but highly presumptuous.

There is nothing particularly unusual about rationalizing failure to solve a problem by advancing the contention that the problem is insoluble–every schoolboy tries this technique when he meets his first difficult arithmetic assignment. The astounding fact in this particular case is that the scientific profession is not only getting away with this preposterous excuse for failure to reach its objectives, but is also well on the road to persuading (or browbeating) the philosophers into modifying or eliminating the long-standing philosophical principles which so clearly brand the most highly publicized conclusions of modern science as illogical and untenable. "The problem," says Hesse, "has been to make sense of the apparently paradoxical statements which physicists have been led to make in formulating the new theories."[151] In this strange situation, those who cannot "make sense" of their theories, and find that these theories cannot qualify as logical or reasonable, are attempting (and to a considerable degree succeeding in the attempt) to force a redefinition of logic and reason.

Even the originators and the strong supporters of these modern theories freely admit that they strain credulity to the utmost and border on the absurd. Heisenberg, for example, speaking of the Copenhagen interpretation of quantum theory, says:

> It was not a solution, which one could easily accept.... I repealed to myself again and again the question: Can nature possibly be as absurd as it seemed to us in these atomic experiments?[152]

The present general acceptance of these Copenhagen doctrines by the physicists does not mean that the logical situation has changed in any way. The explanations, which they offer, are just as absurd as Heisenberg found them originally, but the physicists simply feel that they have no other choice. As James B. Conant puts it, they "have learned to live with a paradox that once seemed intolerable."[153]

The argument which is relied upon to support such inherently implausible theories and to justify the contention that it is nature that is absurd, rather than the products of the theorists, is always the alleged lack of any alternative. "There is no other way,"[88] as Einstein puts it. All through the literature of modern science this same argument is repeated over and over again. It echoes as a familiar refrain in the statements quoted in the earlier pages. "There was and there is now no alternative,"[70] asserts Millikan. "There are no physical laws to tell us—and there cannot be,"[116] contends Bronowski. Physicists have made "a thorough-going analysis of all conceivable alternatives,"[56] reports Sherwin. The "only interpretation" of newly discovered facts, says Bridgman, is "that nature is intrinsically and in its elements neither understandable nor subject to law."[15] There is no "'intelligible alternative" currently available, hence we must accept present-day theories even though they are "conceptually imperfect" and "riddled with inconsistencies,"[30] Hanson tells us.

It cannot be denied that there is a certain amount of force to this argument when it is used as Hanson is using it, not in support of current theory *per se,* but as a reason for utilizing such theory pending the possible development of something better. But no matter how it is used, it is a very vulnerable argument, since it is immediately and utterly demolished as soon as the allegedly non-existent alternative is produced. The presentation of such alternatives in this work has therefore destroyed the foundation of the argument in favor of accepting the conclusions of "modern physics', in spite of their numerous and serious shortcomings.

From this standpoint it is entirely irrelevant whether or not the reader of the preceding pages is convinced by the case therein presented and is willing to concede the validity of the new theoretical

system. The mere *production* of a logical and self-consistent alternative *automatically* invalidates the contention that no such alternative exists, and overturns all theories that rest upon such a contention. The kind of a wholesale demolition of claims of this nature that has been carried out in this work goes even farther; it demonstrates that any contention that there are no more alternatives is unsound; that the human race has not yet arrived at that degree of infallibility which would make it legitimate to assert that all possible alternatives have already been examined.

Philosophers already knew this—it is the kind of a conclusion that is readily derived from philosophical considerations–and it is unfortunate that they have not been more outspoken in their criticism of scientific doctrines that justify the advocacy of irrational theories on the ground that there is no "intelligible alternative". Feyerabend makes this comment:

> Philosophers of science … have become rather tame (or beat) and are much more prepared to change their ideas in accordance with the latest discoveries of the historians, or the latest fashion of the contemporary scientific enterprise. This is very regrettable, indeed, for it considerably decreases the number of the rational critics of the scientific enterprise.[154]

The findings of this present work now provide some strong reinforcement for those who take their stand on sound logical and rational principles. Here the great handicap of science, the very narrow factual base on which each of its conclusions rests, a base "derived from only limited groups of phenomena," as Heisenberg puts it, is overcome by the construction of a completely integrated theoretical structure which has the support of an enormous number of positively known facts derived from all types of physical phenomena. The Reciprocal System is thus far better equipped than any of its predecessors to take issue with philosophical principles should this be required but, as could safely be predicted from elementary considerations based on the concept of a rational universe, when science thus puts its own house in order there is no longer any point at issue. The findings of the present development are completely in harmony with both philosophy and common sense.

In every case where present-day science insists that we must accept illogical, unreasonable, and paradoxical conclusions because there are no alternatives, this work has produced sound, logical and consistent

alternatives. There is no longer any justification for the contention that we *must* accept an incomprehensible wave-particle duality, that we *must* abandon the concept of absolute magnitudes, that we *must* give up the idea of causality, and so on. The position of those philosophers who have always opposed the uncontrolled excursions of science into realms of fantasy beyond the reach of sound philosophical and common sense principles is thus fully vindicated. In retrospect, the words of some of these individuals have a distinctly prophetic ring. Consider the following from Maritain, for example:

> Metaphysics … renders mathematical physics the essential service of protecting it against distortions that would be almost inevitable without it; above all against the harmful illusion that leads it to regard itself as a philosophy of nature and to believe that things begin to exist only when they are measured by our instruments.[155]

In view of the great amount of discussion, both in scientific and in philosophical circles, about the issue of determinism, it may be well to emphasize that the return to strict causality in the Reciprocal System does not imply a deterministic universe. The two concepts are often confused in current thought. As Lindsay says, '"There is some disagreement among scientists about the concept of causality. Among many it is essentially equivalent to the notion of *determinism*."[156] But the statement that A *causes* B does not include the assertion that *all features* of B are *determined by* A. The latter is determinism; the former is causality.

This distinction is somewhat obscured in a universe composed of "things"—entities that are essentially permanent. Determinism, in the Laplacian sense, visualizes the behavior of all entities in the universe as analogous to the behavior of the molecules of a gaseous aggregate, where it theoretically would be possible (assuming an isolated system) to specify the conditions at any future time if the initial conditions were given. But we do not live in a universe of permanent "things"; we live in a universe of motion, and the existence, in this universe, of transformation processes by which the various combinations of motion that constitute the entities of the physical universe change their forms and identities rules out determinism.

Causality can be maintained through a series of such processes, but not determinism, as the properties of entity A are not the same as those of the entity B into which it is transformed, and hence directional

specifications cannot be carried forward from one phase to the next, nor is it always possible to specify what *form* the product will take. The photon, for example, is transformed into thermal motion when absorbed by matter. Later, that thermal motion is again transformed into another photon of radiation. A complete causal chain is maintained. The absorption of the photon causes a minute increase in the thermal motion of the matter, and hence in its temperature. The increased temperature then causes the radiation from this aggregate of matter to be speeded up to the extent of emitting one additional photon. But the deterministic connection is broken. The direction of the incident photon has no bearing at all on the direction of the emitted photon, the latter being determined entirely by probability considerations. The Reciprocal System introduces a host of new transformation processes which operate in a similar manner—transformations of one kind of a particle into another, transformations of matter into radiation or kinetic energy, transformations of motion in space into motion in time, and so on—and each of these processes breaks the deterministic relation, even though it maintains the causal connection.

Like the emission of a photon, the emission of an electron, a radioactive particle, or some other unit, is always due to a specific cause, but just as in the case of the photon, there is some aspect of the emission process, which is indeterminate. The photon actually has no direction of its own, because it has no independent motion (aside from the vibratory motion that makes it a photon). The translational motion, which we observe is supplied by the progression of space-time, and since the progression, is scalar, the direction which the photon will take is purely a matter of chance. Whether or not it will ultimately impinge on some particular distant object is therefore a question of probability; the original influence can cause emission but it cannot *determine* where the photon goes.

This is a much different picture of the situation than the one we get from modern physics, which denies the existence of specific identifiable causes for events at the microphysical level. In the words of Bridgman, Whenever he (the physicist) penetrates to the atomic or electronic level in his analysis, he finds things acting in a way for which he can assign no cause, for which he can never assign a cause, and for which the concept of cause has no meaning, if Heisenberg's principle is right. This means nothing more nor less than that the law

of cause and effect must be given up.[157]

However bravely the modern physicist may talk for publication, this is not the kind of a situation that any believer in the rationality of the universe as a whole can contemplate with equanimity, and Bridgman reveals his own disquietude about the subject in the following rather plaintive statement:

> The physicist thus finds himself in a world from which the bottom has dropped clean out; as he penetrates deeper and deeper it eludes him and fades away by the highly unsportsmanlike device of just becoming meaningless. No refinement of measurement will avail to carry him beyond the portals of this shadowy domain, which he cannot even mention without logical inconsistency.[158]

The findings of this present work now give the scientist an opportunity to escape from this awkward dilemma; they enable him to maintain strict scientific conformity with the facts of observation while remaining wholly within the bounds of logic and rationality. From a scientific standpoint, the most significant thing about the new theoretical system presented in this work, the Reciprocal System is that it is in agreement with all positively known facts or, at least, is not inconsistent with any of them. From a philosophical standpoint, its most significant feature is that it is in harmony with nature; it does not picture nature as "absurd," or "meaningless," or "paradoxical." It defines a universe that is logical, orderly, and rational, and that is readily understandable in all of its details, if a reasonable effort is made to look at natural processes as they actually exist, not in some artificial context imposed by human preferences and prejudices.

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